nissiles and rockets

HE MISSILE/SPACE WEEKLY

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TECHNOLOGY DEPARTMENT

V.8 #5

Special Report

Kennedy's Big Decision

Should He Order Nike-Zeus Production Now?

Zeus Gets 3rd Stage

AN AMERICAN AVIATION PUBLICATION

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- ADVENT Communications Satellite (Early Development Stage)
- Discoverer Satellite Recovery Capsule (Flight Test Stage)
- APOLLO Manned Space Vehicle (Also, five other Manned Space Vehicle Study Contracts)
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THE MISSILE/SPACE WEEKLY

missiles and rockets

Volume 8, No. 5 January 30, 1961

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THE COVER

Technicians at Army's White Sands, N.M., facility attach third stage to the Nike-Zeus. A comprehensive report on the controversial antimissile missile starts on p. 26.

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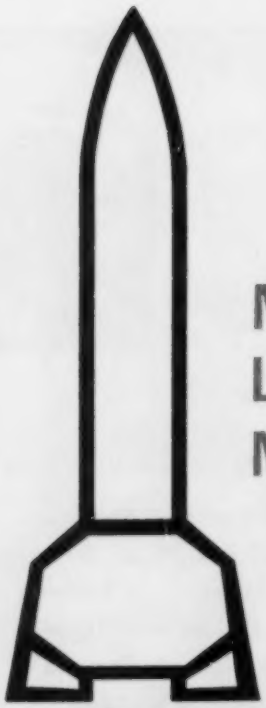

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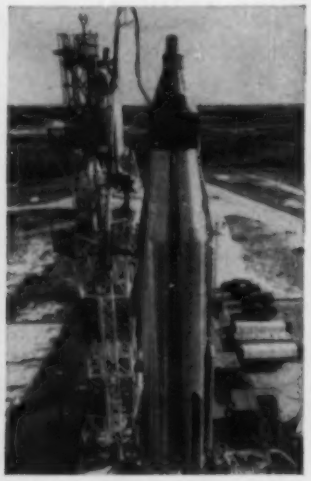
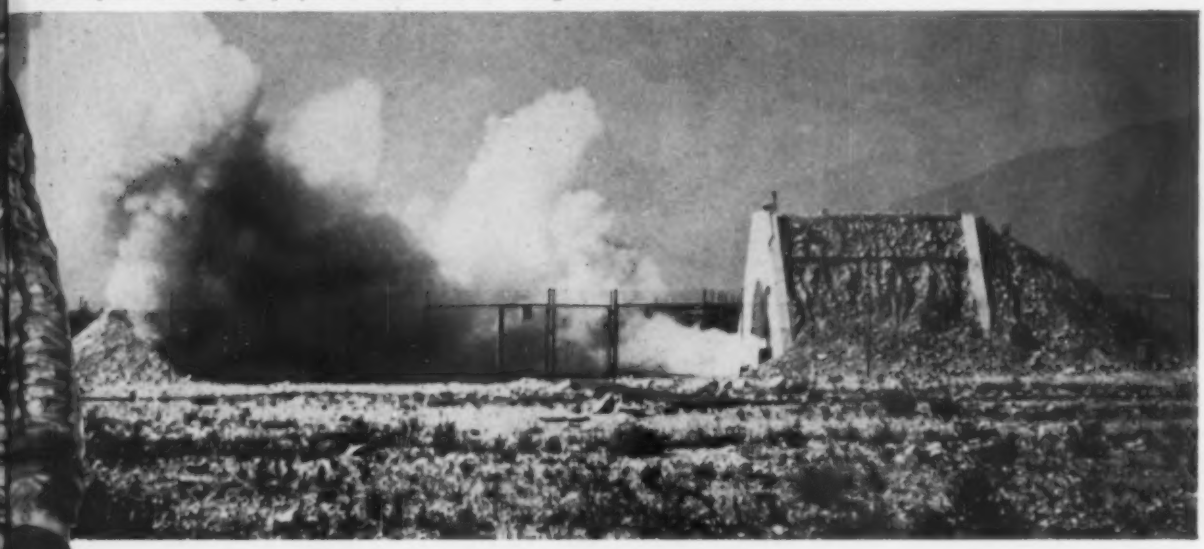
Mock-up of Project Mercury capsule, built by McDonnell Aircraft Corporation for the manned orbital flight program of the National Aeronautics and Space Administration.



In "Big Joe" test launching, full scale model of Mercury space capsule was boosted 100 miles high atop this Air Force Atlas missile. Capsule was protected by a B. F. Goodrich laminated glass fibre and resin heat shield fabricated under subcontract to General Electric.

SUITING UP THE ASTRONAUTS The pressure suits to be worn by the Astronauts are now being fitted by B. F. Goodrich. This suit must maintain enough pressure to keep a man's blood from boiling, must provide air to breathe, must protect against searing heat. In the bargain, this pressure suit is light weight and flexible enough to allow free movement.

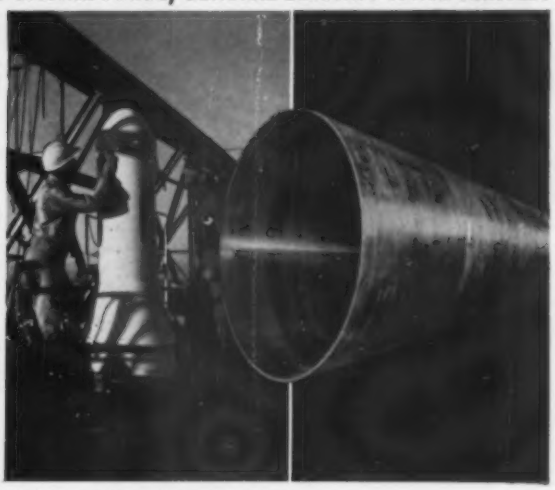
HIGH ENERGY SOLID PROPELLANTS This static test stand is one of 56 specialized facilities at the B.F.Goodrich solid propellant plant...currently processing and loading solid fueled motors of the LOKI, RTV and ASP types. BFG pioneered the development of the major polymeric binder-fuels now being used in the most advanced missiles.



B.F.GOODRICH ABLATION SHIELDS ARE USED ON THESE U.S. AIR FORCE/GENERAL ELECTRIC SPACE VEHICLES

RVX-2 Re-entry/Recovery Vehicle, the largest ablation-type re-entry vehicle to travel full ICBM-range and be recovered.

Satellite Aeromedical Re-entry/ Recovery Vehicle for USAF Discoverer Program.



Mark-3, an advanced operational-type re-entry vehicle for the Air Force Atlas.

B.F.Goodrich aviation products

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Over 250 of these reliable vehicles have been launched since 1946—forty during the IGY alone. Typical missions include: studies of atmospheric composition; micrometeorite investigations; ionization, radiation, and magnetic field determinations; aeromedical experiments; high-altitude photography; re-entry problems; communications; and component testing.

Aerojet emphasizes the delivery of complete units ready for payload insertion, followed by overall program management. Included are engineering, field service; logistics, range operation, ground handling equipment, data reduction, and training of customer personnel.

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The Countdown

WASHINGTON

Defense Dollars and the Congress

Chances of President Kennedy winning larger defense appropriations from Congress are looking up. Among key leaders with whom he is gaining support is Sen. Carl Hayden, the seldom-outspoken chairman of the Senate Appropriations Committee. Hayden has gone on record as saying flatly that "in the face of the continued Communist menace" Congress can expect to appropriate "much more" for defense.

Titan II Enters the Space Race

Martin's *Titan II* is now a strong contender for the job of being one of the nation's major space boosters in the mid-60's. The Air Force this last week officially put *Titan II* in the space business by making it the booster for the *Dyna-Soar* program. The plan to use the less powerful *Titan I* has been dropped.

Minuteman Moves to the Pad

After nearly a month of minor delays, the Air Force this week again hoped to launch its first R&D *Minuteman* from Cape Canaveral. The big solid-fueled ICBM was scheduled to be given a complete system test from a pad. The first launch of an R&D bird from the silo at the Cape is planned about early summer.

Snag in Space Frontier?

Is there any significance in Kennedy's long delay in naming a new NASA administrator? Insiders are wondering if it presages a downgrading of the civilian space effort—or whether he just couldn't decide how he wanted to "redirect" it.

Tiros: Paternity determined

A bubbling question in Washington for some time has been who is the "father" of the successful *Tiros* weather satellite. Some said NASA. Some said the Air Force. Some said the Navy. Some said . . . take your choice. Now the American Meteorological Society has made a determination. It presented its "special award" to Dr. Stanley M. Greenfield, an Air Force scientific adviser, and Dr. William W. Kellogg of Rand for providing 10 years ago the "framework which is basic" for the *Tiros* system.

INDUSTRY

Cheaper Bullpups

Martin-Orlando is driving for a 75% reduction in the cost of *Bullpups*. It says that in two years it has chopped cost per missile about 60%—bringing the present pricetag to the neighborhood of $4,000 per missile. Further reductions are expected from a new campaign to get vendors to drop their prices by 30%. Cuts to date were possible, Martin says, by eliminating all test equipment after bird leaves factory, making three main components (tail assembly, propulsion section and warhead) interchangeable so that Navy and Air Force can assemble them like rounds of ammunition.

Seeker for Zeus?

Western Electric is "sold" on command guidance for *Nike-Zeus* (see special report starting page 26) but does not rule out possibility of shifting to seeker (probably IR) in following versions.

Dyna-Soar Power Bidders

Finalists in the *Dyna-Soar* accessory power systems bidding are said to be Sundstrand Turbo, Walter Kidde & Co. and Thompson Products TRW team. Winner may be named about Feb. 14.

R&D Intelligence

Navy will begin evaluating *Eagle* Air-to-air missile at Point Mugu about mid-year . . . Boeing, under an ARDC $100,000 contract, is filament-winding 3100-gal. rocket-fuel tanks with spun glass threads . . . For NASA, Douglas is studying use of earth orbits to launch lunar and interplanetary flights . . . Cal-Val is getting set to test a water injection system designed to reduce liftoff noise, vibration, heat and pressure. It could mean simplifying missile base design . . . $100,000 NASA contracts are putting Lockheed on a study of using *Thor-* and *Atlas*-launched *Agena* satellites for rendezvous and United Aircraft Labs on a study of mission data and launch dates for planetary orbits with ion propulsion vehicles.

Hébert Back in Business

Rep. F. Edward Hébert and his House Armed Services Investigating Subcommittee are expected to resume inquiries into defense contracting in the near future. One of the top committee targets: Alleged overpricing in military procurement.

INTERNATIONAL

Swedes to Make Falcon

Licensing arrangement is reported almost complete for the manufacture of the U.S. *Falcon* air-to-air missile in Sweden. Agreement has been in the works since last April.

Overseas Pipeline

Britain and Russia are sending electronics delegations to each other's countries, to tour factories and give lectures on current developments . . . France's government-controlled SEREB rocket agency has been allocated $20 million for development of an IRBM—said to have 2000-mile range and solid fuel.

Chinese A-Test

Latest word from over the Bamboo Curtain has Red China getting ready to fire its first nuclear device from a 300-ft. tower in the desert of Sinkien province this year. Yield of the device is said to be 20 KT. It's reportedly made from Chinese-produced uranium.

Western Electric manages the industrial team for Nike Zeus

Western Electric is proud of the responsibility assigned to it as leader of the Army's Nike Zeus industrial team of companies which brings together broad and diverse capabilities.

The selection of Western Electric as prime contractor was based on the qualifications and experience the Company has developed as manufacturing and supply unit of the Bell System. Western Electric and its partner, Bell Telephone Laboratories, work side-by-side as a team in providing the Bell System with communications products of the uncommon quality and reliability necessary to the operation of a completely integrated nation-wide communication service.

The reliability standards and the "sense of system" Western Electric employs in its telephone job are directly pertinent to the requirements of Nike Zeus. And it follows that Bell Laboratories accepts major development responsibilities in the Nike Zeus program, along with Western Electric.

In addition to their joint work for the Bell System, both Western Electric and Bell Telephone Laboratories bring major defense-project experience to Nike Zeus, from such missile programs as Nike Ajax, Nike Hercules, Terrier, and Titan. Other prime contracts in which the Bell System has played an important part include: DEW Line, White Alice, SAGE, communications aspects of BMEWS, and underwater sonar system projects. And in America's space exploration program, we are carrying heavy responsibilities in NASA projects: Mercury, Tiros, Echo, etc.

Nike Zeus major industrial contributors headed by Western Electric, prime contractor:

ALLIS-CHALMERS MFG. CO.	Target Track Antenna
ARMSTRONG CORK CO.	Acquisition Radar Dielectric
BURNS AND ROE, INC.	Technical Facilities Design
CONTINENTAL CAN CO., INC.	Target Track Antenna
CONTINENTAL ELECTRONICS MFG. CO.	Acquisition Radar Transmitter
DOUGLAS AIRCRAFT CO., INC.	Missile, Booster, Missile-handling & Test Equipment
DOW CHEMICAL CO.	Acquisition Radar Dielectric
GOODYEAR AIRCRAFT CORP.	Acquisition Radar Antenna
GRAND CENTRAL ROCKET CO.	Sustainer & Jet-head Motors
LEAR, INC.	Stable Platform
NARMCO MFG. CO.	Target Track Antenna
REMINGTON RAND UNIVAC	Computers
SPERRY GYROSCOPE	Target Track Radar Transmitter
STEEL PRODUCTS ENGINEERING	Missile Track Radar Antenna
STROMBERG-CARLSON CO.	Test Equipment
TEXAS INSTRUMENTS, INC.	Tactical Displays
THIOKOL CHEMICAL CORP.	Booster
VICKERS INC.	Target Track Antenna

In addition to these 18 companies, hundreds of other "partners"—many of them small businesses—are taking part in the research and development effort on the Nike Zeus anti-missile missile system.

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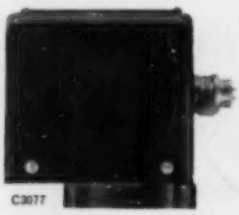

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Sweep:
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Envelope:
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The Missile/Space Week

Shots of the Week

At White Sands Proving Ground, an Army *Hawk* scored a kill on the fastest target missile it has faced. The bagging of a *Corporal* brought to three the types of surface-to surface ballistic missiles *Hawk* has successfully intercepted.

At the Cape: The Air Force's *Atlas D* ended its testing career Jan. 23 by traveling 5000 miles down the Atlantic to bring its total to 35 successes, 8 partials and 6 failures in 49 launchings for the *D* model. The next day, the improved *Atlas E* developed engine trouble and sputtered out after completing only 100 miles of a 5000-mile test.

The Army's *Redstone* missile "satisfied all test objectives" on a 200-mile flight on Jan 23. However, the Air Force's 98-foot *Titan* tumbled into the Atlantic Jan. 20 when the second stage failed to ignite. The test, programed for 5000 miles, was an attempt to duplicate the success which marked the last firing of a liquid fueled missile in 1960.

Nuclear Stage for Saturn?

Three engineers on Wernher von Braun's staff have proposed a nuclear third stage for *Saturn* which would generate 75,000 lbs. of thrust.

Willis Y. Jordan Jr., Donald R. Saxon and Paul G. Thomas of the Marshall Space Flight Center, National Aeronautics and Space Administration, last week told the Institute of Aeronautical Sciences that switching to a nuclear stage would double the *Saturn* payload.

The three-stage vehicle, standing 250 ft. tall, would consist of the *S-I* booster with 1½ million lbs. of thrust, the *S-II* second stage, generating 800,000 lbs. of thrust, and the nuclear stage. The *S-II*, a cluster of four Rocketdyne J-2 liquid hydrogen engines, is to go out to industry for R&D in about one year.

The vehicle would be capable of lifting a 30,000-lb. manned spacecraft and a chemical fourth stage into low earth orbit. The fourth stage would be fueled in orbit by *Saturn*-boosted tankers, and then could propel the craft to circumlunar and lunar landing missions.

L-T Eyes Chance Vought

Ling-Temco Electronics has offered to buy 150,000 shares or more of Chance Vought Corp. stock at an above-market price in its move to gain control of the company.

Already possessors of "more than 10%" of Vought common stock, the electronics company offered to buy shares at $43.50 on a first-come, first-served basis. Chance Vought stock closed Friday on the New York Stock Exchange at about $39.875, but jumped several points by the middle of the week, hovering around $43.

The National Bank of Commerce, Dallas, will serve as escrow agent in the offer. The tender expires Feb. 1 but may be renewed, Ling-Temco announced.

There has not been any official disclosure of just how much Vought stock Ling-Temco now holds. Some estimates have reached 30-40% of the total shares, but Vought president Frederick O. Detweiler has stated that he believed it was "only on the order of 13% to 14%."

Coughlin New M/R Editor

William J. Coughlin, Chief of the West Coast office of American Aviation Publications, has been named editor of MISSILES AND ROCKETS magazine. Coughlin is former head of the London and Moscow bureaus of the McGraw-Hill Publishing Co. and was chief of the San Francisco bureau of United Press. He is a veteran of 15 years of aviation and missile reporting.

Clarke Newlon, executive editor of the magazine, has resigned.

Beryllium Breakthroughs?

The Air Force expects beryllium to break through current limitations in design and fabrication of heat-resistant structures for space vehicles. Maj. Gen. W. Austin Davis, commander of the Wright-Patterson Aeronautical Systems Center, said the metal also offers promise as a fuel additive because of its high energy content. The beryllium program is moving along faster than the

(Continued on page 61)

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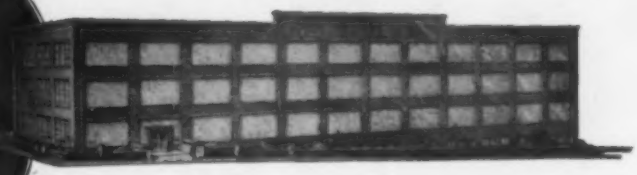

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Size 1½" dia. x 3½" H. Wght. 7 ozs.

Frequencies: 360 to 1000 cycles

Accuracies:
2007-6 (± .02% at —50° to + 85°C
R2007-6 (±.002% at +15° to + 35°C
W2007-6 (±.005% at —65° to + 85°C

Input: 10 to 30 Volts, D. C., at 6 ma.

Output: Multitap, 75 to 100,000 ohms

TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles

Accuracy: ±.001% at 20° to 30°C

Output: 5V. at 250,000 ohms

Input: Heater voltage, 6.3 - 12 - 28

B voltage, 100 to 300 V., at 5 to 10 ma.

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Weight, 14 lbs.

Frequencies:
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Accuracy:
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Output, 10 Watts at 115V

Input, 115V. (50 to 400 cy.)

TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.

Output: 115V
60 cycles, 10 Watt

Accuracy:
±.001% 20° to 30°C

Input,
115V (50 to 400 cy.)

TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
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Weight, 25 lbs.

Frequencies: 50 to 1000 cy.

Accuracy:
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Output: 115V, 75W.

Input: 115V, 50 to 75 cy.

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News of materials for the aerospace industry – selected from the 27,000 products of the 3M Company

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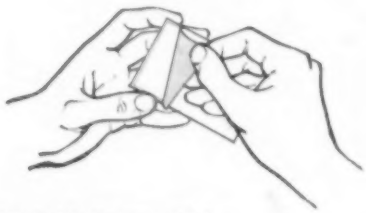

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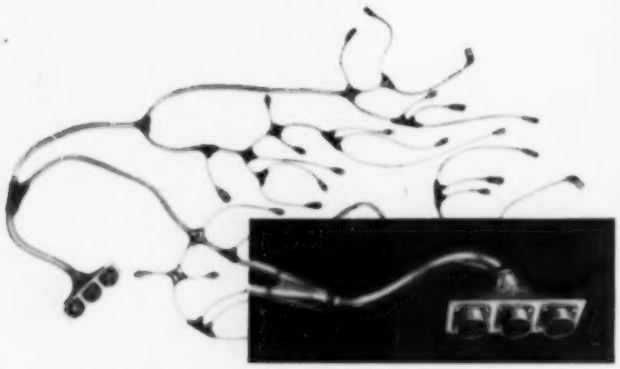
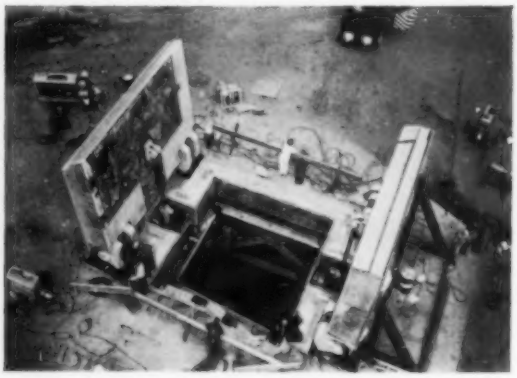


Missile wiring harness—General Electric silicone rubber was chosen by Aerojet-General Corp. for the Titan's propulsion system wiring harness. Breakouts and junctions are molded from G-E RTV (room temperature vulcanizing) silicone rubber; wiring is silicone insulated; jacketing is high-strength G-E silicone rubber. Inset shows silicone rubber inserts in connectors. RTV is used in other missiles as a shock-absorbing encapsulant and potting material for electronic assemblies.



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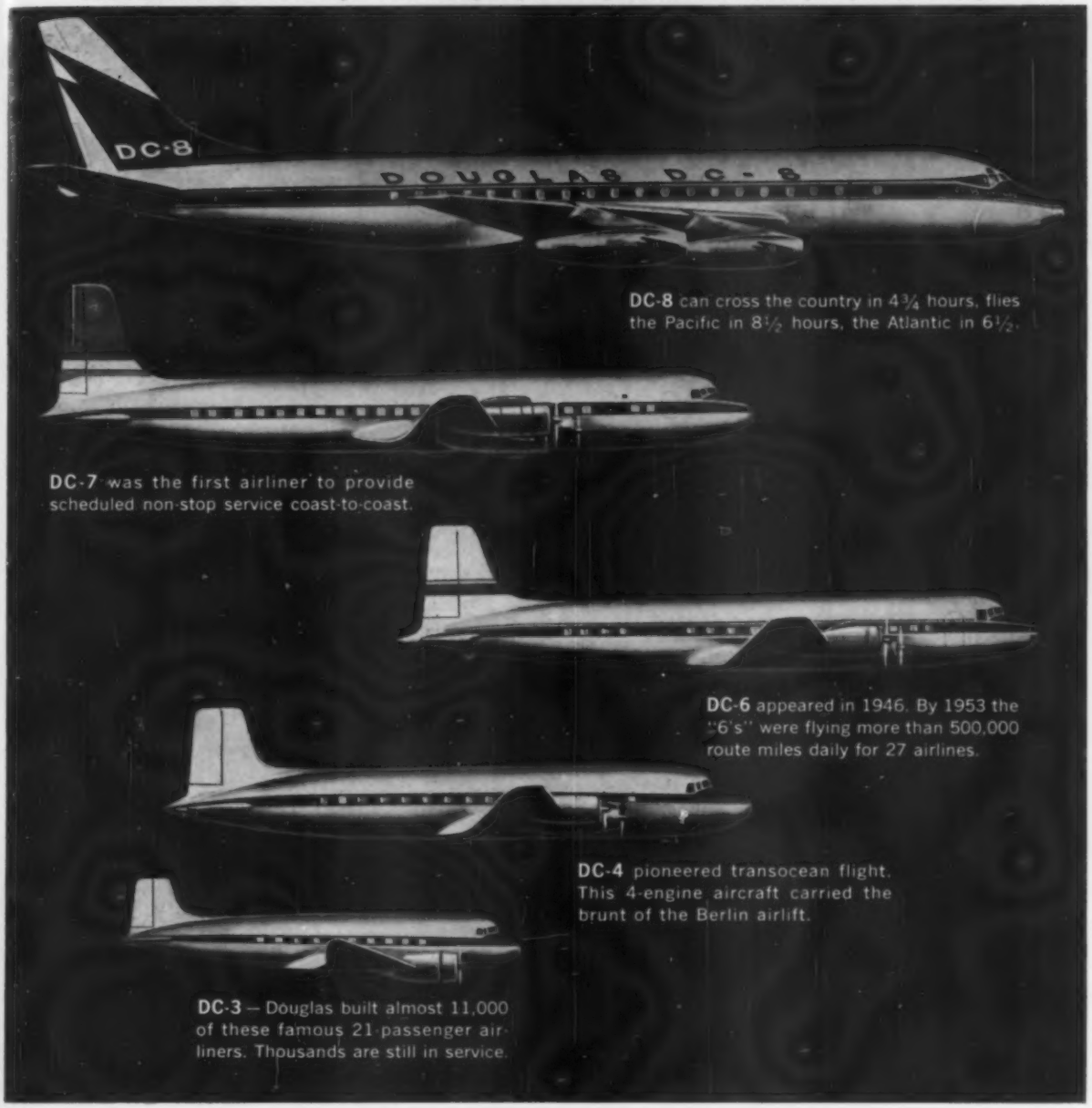
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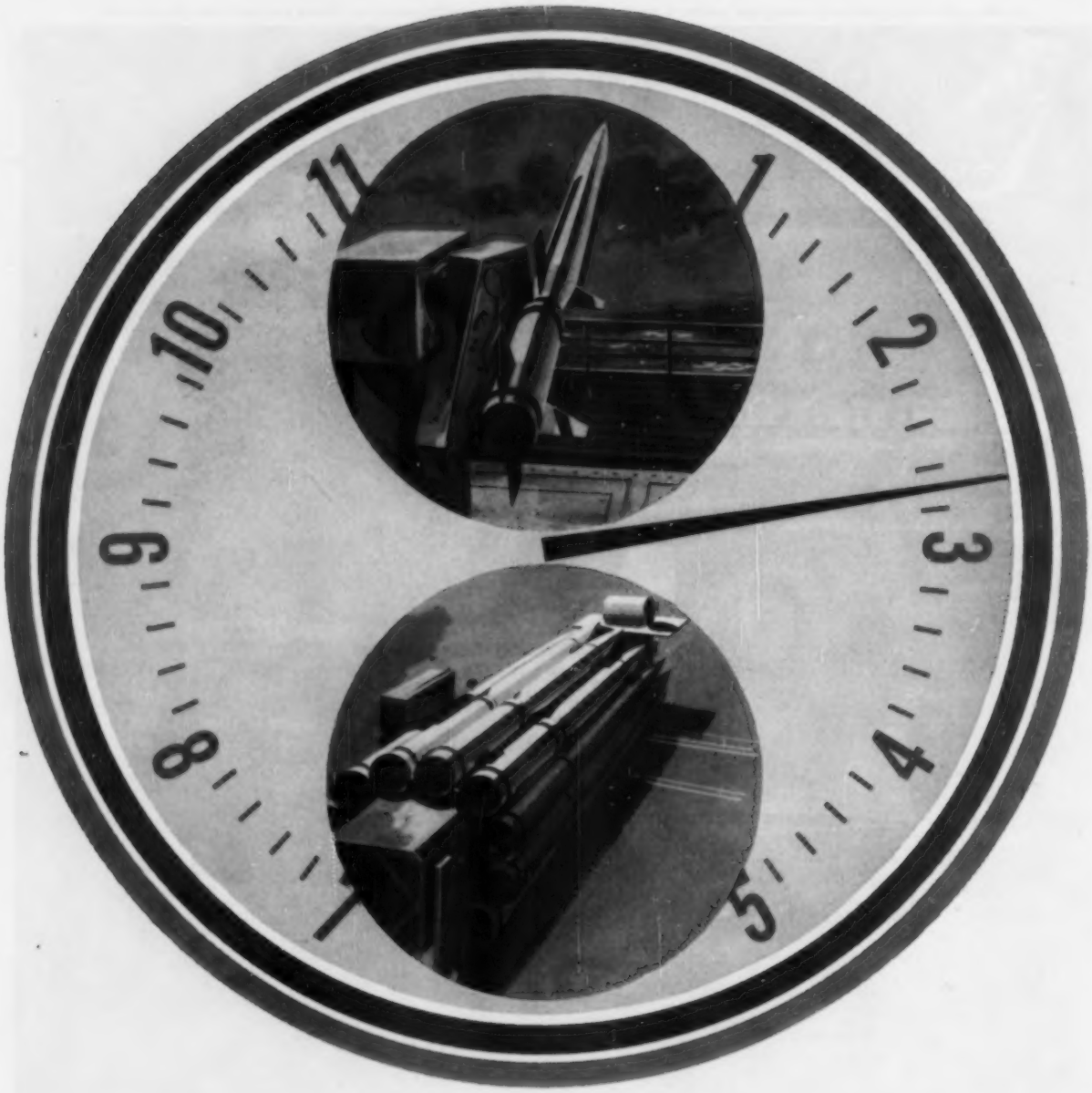

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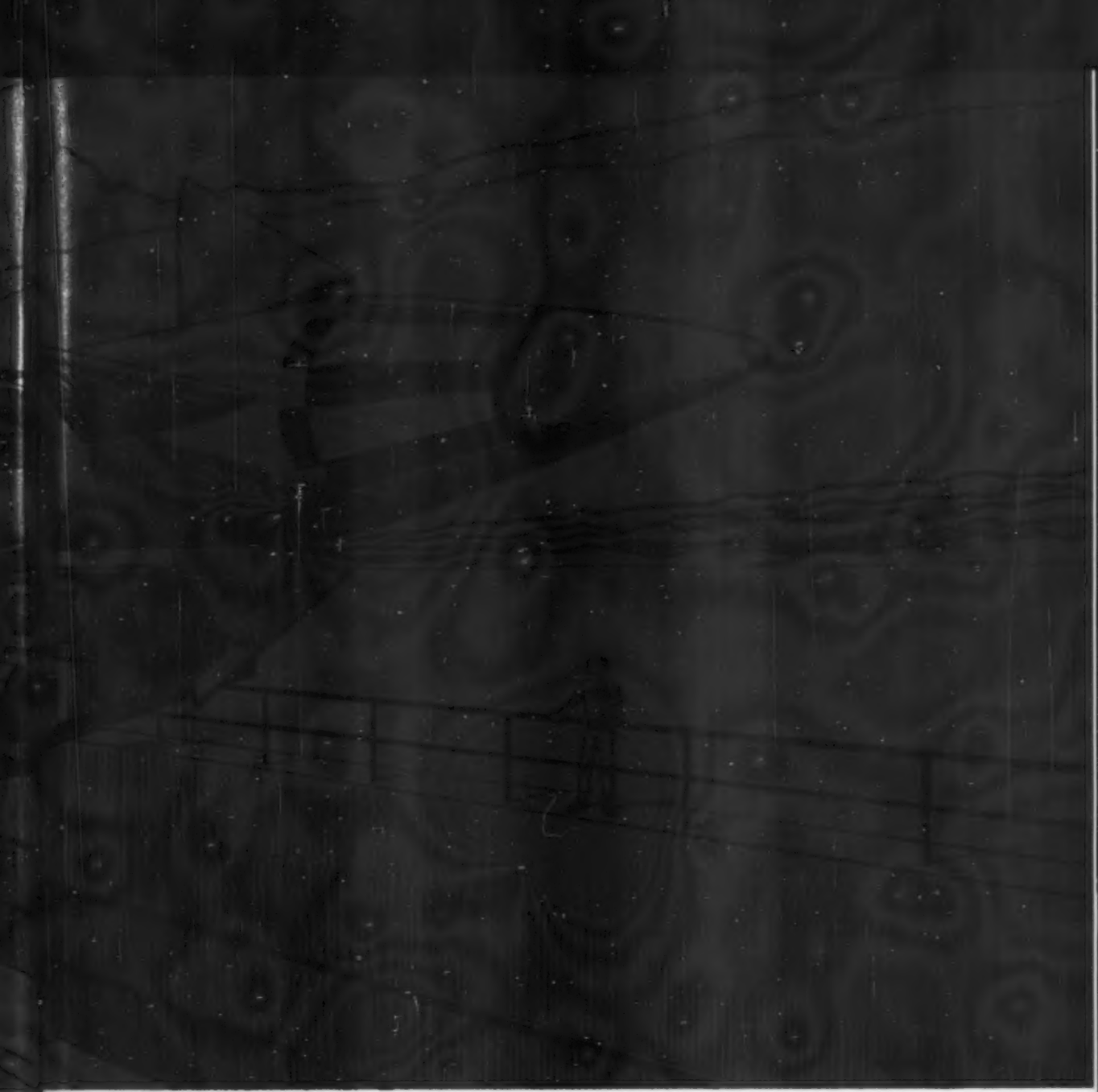
SPECIAL REPORT

NIKE-ZEUS NOW?



by James Baar One of the first critical military decisions demanding President Kennedy's immediate attention is whether to order the controversial *Nike-Zeus* antimissile missile into production. What makes the decision critical is time. *Nike-Zeus* is the only potential active defense against Soviet ICBM's available now, or expected to be available in this decade. Each day that a go-ahead order is delayed is a day lost in beginning deployment—which is three years away at the earliest. What will Kennedy do? Right now he has before him a last-minute recommendation by a top-level military-scientific group that *Zeus* be committed to production. This was left on the White House doorstep with a disapproving shrug by the Eisenhower Administration. But the pressures are great to push this recommendation into a pigeonhole. *(Cont'd next page)*

$8 Billion Investment Gets Strong Backing . . .

If Kennedy acts this winter, the North American Defense Command can be expected to begin manning *Zeus* batteries in early 1964.

That would be more than a year later than would have been possible under the Army's original plan rejected by President Eisenhower.

It would be more than a year earlier than will be possible if Kennedy follows the Eisenhower plan to withhold production money until testing is completed in 1962.

The revised cost of producing and deploying a *Zeus* network to protect the nation's strategic forces and the majority of the U.S. population is estimated to be about $8 billion—a figure lowered considerably in the last year through technical advances in the *Zeus* system.

The inital cost is estimated at about $270 million for the first year.

• **Three-headed problem**—Essentially, there are three factors involved in the decision facing Kennedy:

–The first is technical. The Army and its technical experts have insisted since late 1959 that the *Zeus* system is technically assured and ready to go into production on a concurrent basis with the end of the R&D program. A number of experts outside the Army—including several in key positions have questioned this.

–The second factor is economic. The *Zeus* R&D program including obligations planned in the FY '62 budget proposed by Eisenhower already has cost more than $1 billion. Previous estimates of the cost of deploying *Zeus* have run as high as $13 billion to $15 billion.

–The third factor is strategic. Many military leaders outside the Army contend that the billions of dollars needed for *Zeus* would be better spent on increasing the size of the U.S. arsenal of strategic striking forces. Army leaders counter that without *Zeus* the Soviets are being offered a "free ride"; that *Zeus* would increase tremendously the number of ICBM's the Russians would need for a big war—thereby greatly augmenting U.S. deterrent strength.

All three factors were weighed during the closing months of the Eisenhower Administration by an Ad Hoc *Zeus* Committee set up by Richard S. Morse, director of Army Research and Development. The committee included key representatives of Defense R&E Director Herbert York and then Presidential Science Adviser George Kistiakowsky. Both York and Kistiakowsky have been leading opponents of committing *Zeus* to production.

• **Objections overruled**—The committee found that during the last year the *Zeus* R&D program has remained on schedule; both its time schedule and its dollar schedule. At the same time, many of the previously-questioned technical solutions to the problem of finding, tracking and destroying incoming ICBM warheads were proven to the committee's general satisfaction.

Moreover, two major theoretical arguments that have been used against *Zeus* were determined to have been generally vitiated.

One has been the question whether *Zeus* could discriminate between real warheads and decoys that looked and acted exactly like warheads.

The Army's answer is that after several years of study the only thing that anyone has been able to find that looks and acts exactly like a warhead is another warhead. As one Army official put it: "We can contend with any decoys that anyone in this country can prove to be feasible. We are as advanced as the threat—and more."

A second major theoretical argument that has been used against *Zeus* is the strong belief among a number of scientists that there must be a cheaper and more effective method. For example, destroying an ICBM during its launch phase or intercepting it with a ray or a cloud of particles.

The Army's answer is that ARPA has spent some $300 million on Project *Defender* during the last two years and so far has found no feasible alternate to *Zeus*.

Lt. Gen. Arthur Trudeau, chief of Army R&D and a leading advocate of *Zeus*, recently commented bluntly:

"We must face that if we want a missile defense system in this decade *Zeus* is the only answer known to the Free World. I would like to be able to hit enemy ICBM's on the launching pad. I'd like to hit them as they come out of the factory door. But today *Zeus* is the only practical system."

In the field of military strategy, the committee particularly considered increasing military demands for an active antimissile defense. One of the principal leaders in making these is Air Force Gen. Laurence S. Kuter, commander of NORAD.

Finally, the committee read recent intelligence reports that the Soviets have an antimissile missile under development.

• **Recommendation unavailing**—In the end, the committee recommended to Morse that the Army should immediately begin production of *Nike-Zeus* on an "interim" basis. The report was passed on to the Office of the Secretary of Defense, but no change in policy resulted.

The final Eisenhower budget called only for obligating about $250 million more in FY '62 for *Zeus* to complete the test program. There was no money for production. Moreover, Eisenhower stated flatly in his budget message:

"Funds should not be committed to production until development tests are satisfactorily completed."

The "interim" production program proposed by the committee is based on the minimum number of batteries that it would be feasible to manufacture.

The cost the first year would be about $270 million. The cost the second would be about twice as much.

Such a program would offer two considerable advantages: It could be expanded after the first year to the full program sought by NORAD without any loss of time. It could be greatly expanded after two years with only some loss of time. Deployment of the first batteries still would be possible in 1964.

Essentially, the committee's recommendation is saying that the saving of nearly two years in time is worth the investment of about three quarters of a billion dollars.

"If you never went beyond the interim program at all, *Zeus* would be highly useful," one Army official argued recently. "At the very least you would have some means of taking care of mistakes.

"The odds are that sooner or later one of these ICBM's is going to get loose and then what do you do? Even a limited number of *Zeus* batteries would solve the problem."

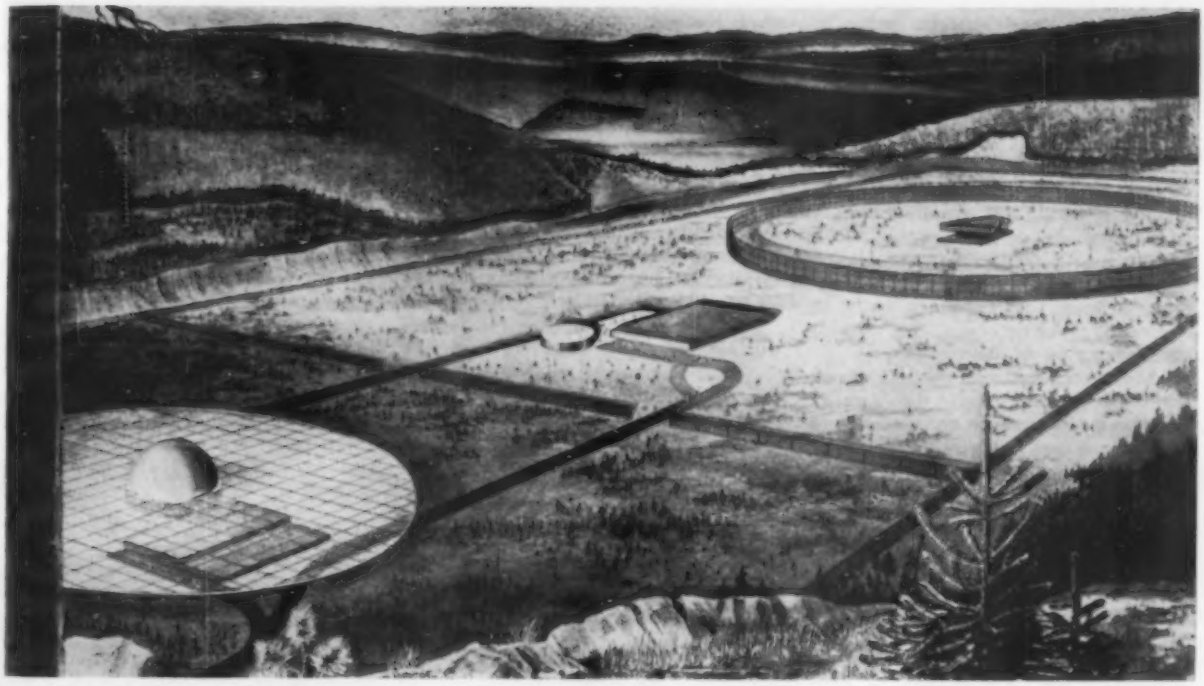
• **The big question**—But such considerations are merely side issues. The central issue before Kennedy is whether

Army programed spending on Nike-Zeus

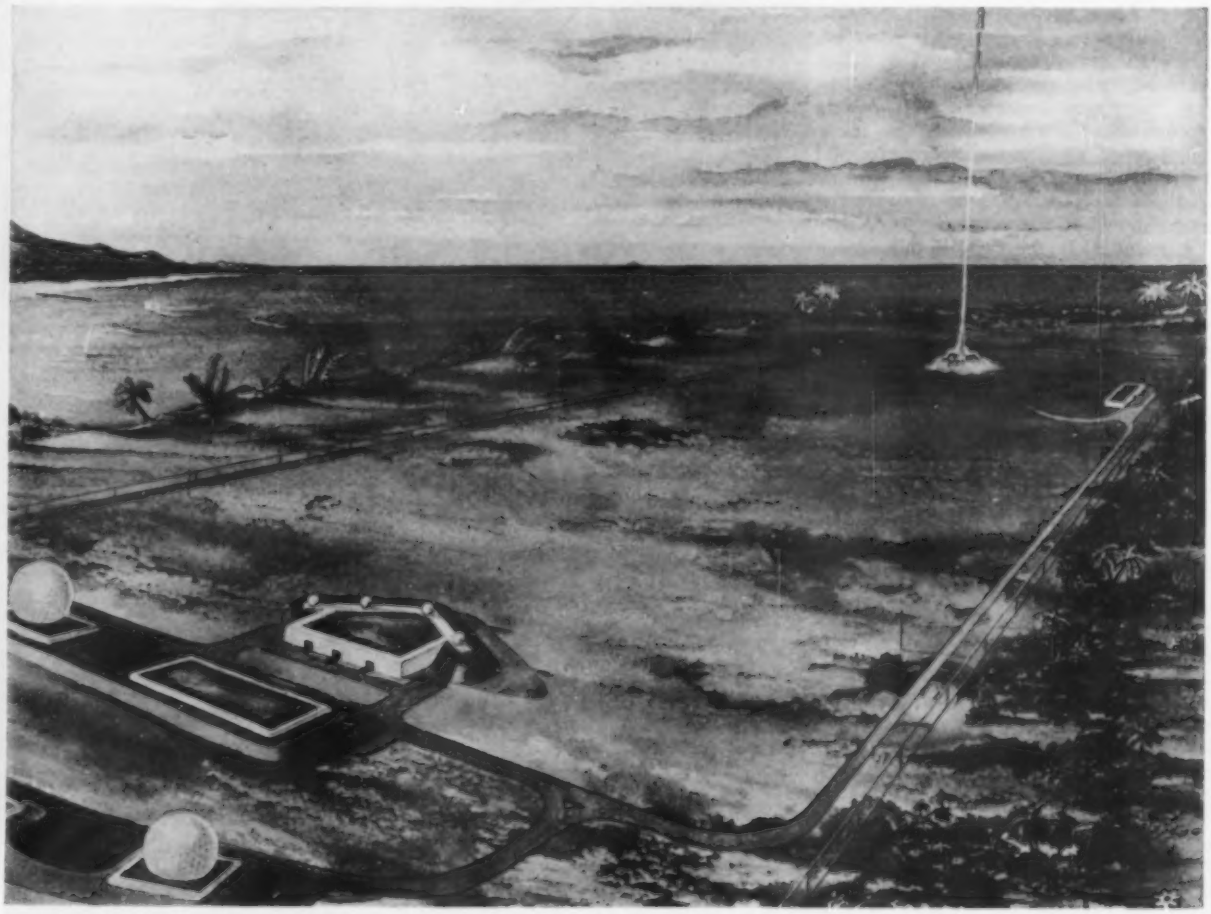
(in millions)

FY '57 and previous	$12.2	(R&D)
FY '58	55	(R&D)
FY '59	210.6	(R&D)
FY '60	297.8	(R&D)
FY '61	302	(R&D)
	22	(Pre-production
FY '62	about 250	(R&D)

(Nearly half of all money going into the Army Guided Missile Agency is for Zeus. About one quarter of all money going into the overall Army Ordnance Missile Command is applied to Zeus.)



ARTIST'S CONCEPTIONS OF SYSTEM in operation. ABOVE: Nike-Zeus Defense Center, where oncoming ICBM's would be detected and targets assigned to batteries. Acquisition Radar Receiver is at left, Transmitter at right. BELOW: missile is launched from typical battery site. In foreground are the Discrimination, Target Tracking and Missile Tracking Radars.



he considers *Zeus'* strategic value in the Cold War worth the price.

One way of weighing *Zeus'* strategic value is to consider what would happen to the East-West arms balance if Russia had it.

Zeus is considered capable of intercepting a sizable majority of all oncoming ICBM's. But granting it only an effectiveness of 50% would mean that if Russia deployed it the United States would have to expand its strategic striking forces tremendously in order to maintain even the present narrow margin of deterrence.

Moreover, the introduction of an antimissile system into the already complicated deterrence equation would introduce a new element of doubt of great value and significance.

As of today, the ICBM is unstoppable once launched. Therefore, all calculations as to its effectiveness are based on its technical reliability. Active defense measures do not have to be considered as they have had to be for years in the case of strategic bombers.

An antimissile missile would change that completely. The element of attrition over the target would become a fact that would have to be again faced by military strategists for all of their weapons.

• **'Great promise'**—This is the kind of military thinking that has been behind the repeated pleas by Gen. Kuter for beginning the production of *Zeus*.

"Our most immediate and pressing requirement in aerospace defense is for a defense against the intercontinental ballistic missile," he said last April.

"Opinions regarding the Soviet operational ICBM inventory vary only in number. In the face of this known threat, a threat that could be unleashed by a decision of Soviet leaders, there is a clear requirement for more positive thinking by the scientific community and more positive action in development, construction and placement of an effective anti-ICBM defense system in the NORAD operational inventory."

Then, turning to *Zeus*, Kuter added: "This project has shown great promise in its research and development program. The Department of Defense has announced future firing tests of *Zeus* against ICBM targets of the *Atlas* and *Titan* types. NORAD expects these tests will be successful and has urged the initiation of production . . ."

On January 6 Kuter said essentially the same thing.

Few military leaders agree more than General Trudeau. As he succinctly put it:

"We dare not become so criminally complacent that we don't even try to defend ourselves."

• **Interest grows**—Regardless of what Kennedy may do about *Zeus*, there is increasing interest in the program in Congress. As the capabilities of the *Zeus* system become more apparent, it becomes more difficult for opponents to justify delaying production. At the same time, public statements by military leaders have led to a growing awareness of a need for some active defense against the ICBM.

A number of early hearings by various congressional committees are already being considered.

As always, one of the key factors will be cost. But even the sting of that has been mitigated somewhat by the wide circulation of figures showing what the United States has spent in the last decade for defense against the nearly obsolescent Soviet bomber threat.

In the last several years alone, the Pentagon has spent an average of about $3 billion a year on air defense not including *Zeus* R&D. In the last decade, air defense costs have totalled nearly $35 billion.

All factors considered, the chances for a go-ahead for *Zeus* production this year appear to be good.

The basic reason was perhaps best summed up last month by Lt. Gen. Robert Wood, chief of Army air defenses, when he said in a speech:

"In the hands of the Russian, *(Zeus)* would be carte blanche power for blackmail that might make us reconsider our retort of years ago to Barbary pirates about 'not one cent for tribute.' We might pay dearly, for our very lives and freedom are at stake." ¤

RECENT R&D test shot of Zeus. Full operational Nike-Zeus system will be tested against Atlas warheads fired from Vandenberg AFB, Calif., early in 1962.

How To Kill an ICBM

Details of the *Zeus* payload are highly classified, but there is a relatively simple method of killing an ICBM warhead.

Prof. S. Fred Singer described a process involving the action of neutron heating which would render a warhead harmless (M/R, April 6, 1959, p. 37).

Assuming a 1-kiloton warhead for *Zeus*, there is indication that neutron heating effects would be destructive to the enemy object within a mile. This is a speculative figure because of the numerous variables.

Singer points out that it is possible to calculate the extent to which an object in space would be affected by a bomb's energy release by using specific heat data. Applying a Rand Corp. formula, *Roentgens* $4200\ P/d^2$; where P is the bomb's power in kilotons and d the distance in miles, a 1-KT explosion will produce 500 roentgens at a distance of about three miles.

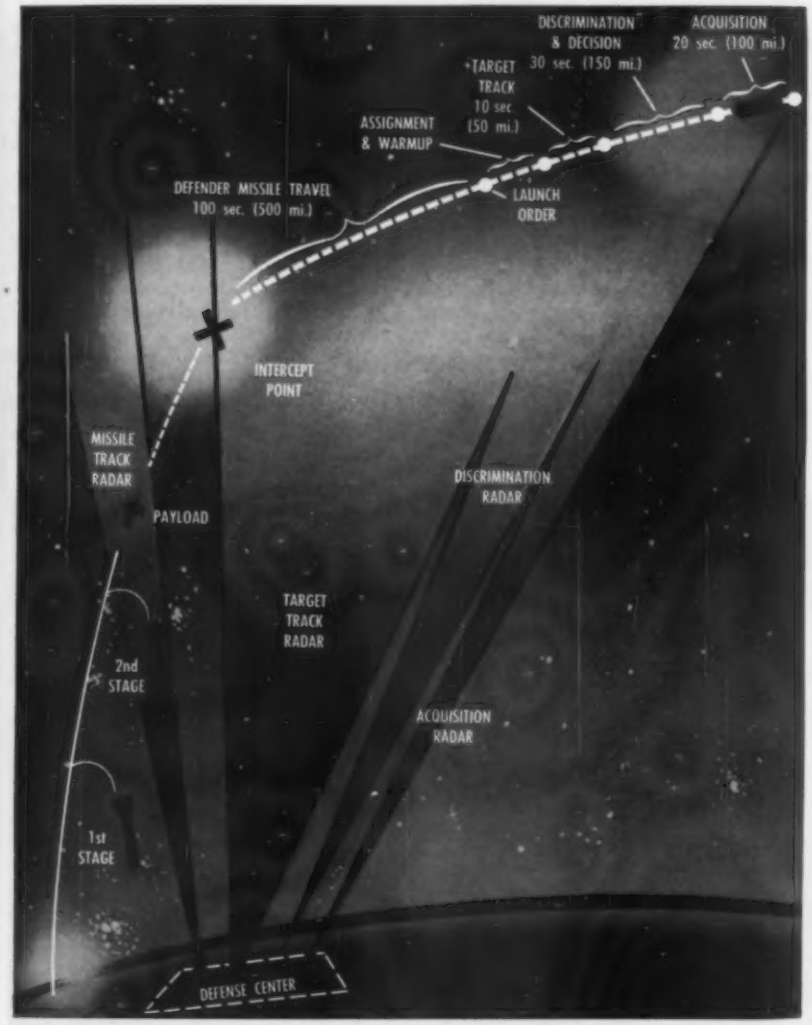
In principle, it is not possible to detonate a nuclear warhead unless the fissionable materials form a critical mass. But if these pieces are large enough to amplify each fission occurring, an incoming neutron will set off many other fissions within the ICBM. This amplification could lead to an internal release of energy, producing temperature changes fatal to the operation of the warhead. ¤

NIKE-ZEUS

Tough Radar Problems Already Solved

R&D work of more than four years has brought some real breakthroughs and confidence that the system is primed for mass production; detractors retreat by stages

by Charles D. LaFond and Hal Gettings



PARAMETERS OF HYPOTHETICAL interception show magnitude of problem of ICBM defense. Assuming warhead speed of 18,000 mph and interceptor speed of 7200 mph, system would have less than three minutes to acquire, define and establish trajectory of enemy warhead and deliver missile to intercept point. This means that primary acquisition would have to be made at ranges of 700-1000 miles.

MUCH OF THE ARMY'S confidence in *Nike-Zeus* as a workable ICBM defense system stems directly from the success of its research and development program.

Begun in 1956 under the Army Rocket and Guided Missile Agency and its prime contractor, Western Electric, the R&D phase undeniably has produced some significant results. Major breakthroughs in acquisition and discrimination radars—key to the concept—have been made and are well on the way to being proved. Some technological advancements are still needed, but the Army is convinced that nothing in the system is now beyond the state of the art. Officials say the system could go into production tomorrow with a running start.

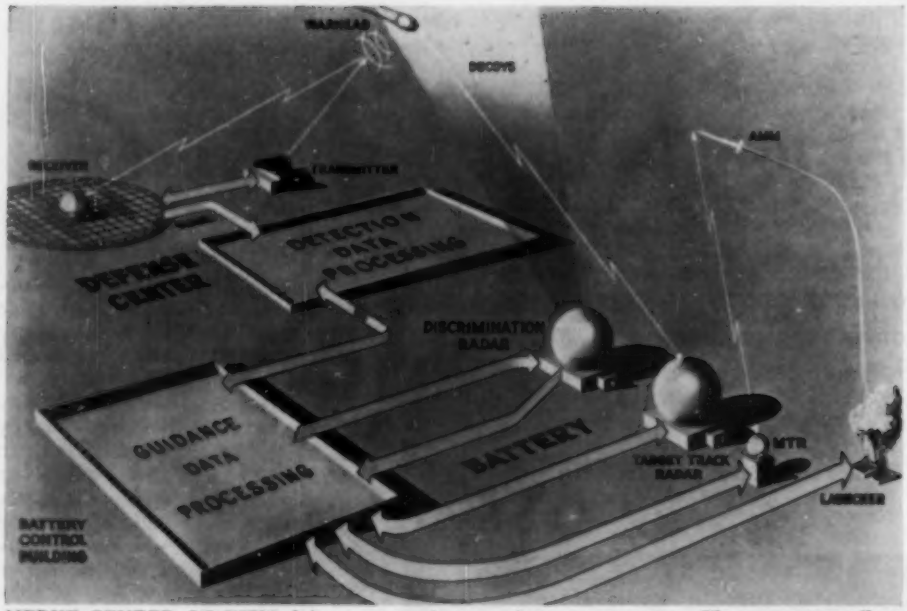
Bell Telephone Laboratories, responsible for R&D system design, has already overcome a host of first-magnitude technical problems. At first look, some of these certainly appear insurmountable. And many of *Zeus'* detractors are not convinced that they have been, or can be, solved.

But square-jawed Lt. Col. Glenn Crane, ARGMA's "Mr. Zeus," has a pat answer for the technical opposition to some of the advanced approaches involved in the program.

"Our detractors usually go through a three-stage metamorphosis," he says. "First, they state flatly that it can't be done. Then when they see us doing it, they admit that maybe it's not impossible after all. Finally, when the concept is fully proven, they will pat us on the back and say they knew all along that we could do it."

No one, pro or con, will deny that ARGMA bit off a large chunk when it set out to develop the *Zeus*. The system must be able to detect very small objects coming in from high above the atmosphere at speeds in the 15-20,000 mph bracket. It must identify and track multiple targets, and discriminate between real targets and decoys—and at speeds and ranges far beyond the capability of any other system. Finally, it must be able to launch and control defender missiles to intercept and kill the incoming warhead—at altitudes high enough to safely detonate a nuclear explosion without harm to the earth below.

Actual ranges and other perform-



NERVE CENTER OF ZEUS defense system is target intercept computer. The computer collects and processes incoming data from the various radars to define the target and its trajectory, and launch and guide the antimissile missile to its kill.

The *Zeus* system is no collection of black boxes and off-the-shelf components that can be put together by an amateur on weekends. Without the system approach, design concurrency, and forceful and intelligent management, it is extremely doubtful that a program of this size could be put together in a millenium. The sheer magnitude and complexity of such a system with its problems in design, engineering, and production is enough to make its successful development seem impossible even to the initiate. The Army admits that the impossible does take longer.

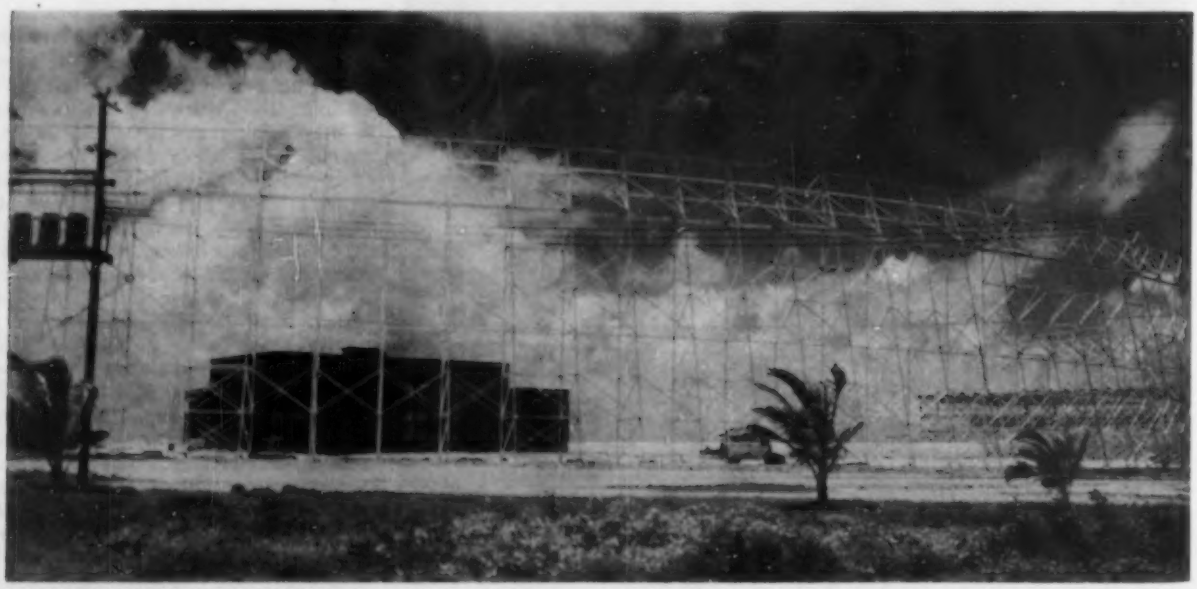
The operational *Zeus* installation will be a vast complex of radars, command and control equipment, and missile batteries —all tied together by an extensive computer complex.

Radar is, of course, the prime component of the system. Several technical breakthroughs were necessary to get the equipment needed. Ranges, powers, precision, and discrimination capability are all beyond conventional radar performance.

Operational requirements for the antimissile system—speed, range, intelligence, accuracy—are of an order not encountered in any existing system. Total time available for the system to

ance requirements of ICBM defense are, of course, classified. A look at a hypothetical problem will, however, give an idea of the problems involved. Logical assumptions as to speeds, travel and delivery items, radar characteristics, communications and computational requirements, etc., show that the operating parameters of such a defense system are enough to shake even the most optimistic designer.

• **System approach vital**—Army stresses the system approach as a large contributing factor in the success to date of the *Zeus* program. It contends that such a concept worked well in both the *Ajax* and *Hercules* systems and has been carried even further in the *Zeus*. To back this contention further, Army also points to Navy's *Polaris* and its ahead-of-schedule development. In fact, ARGMA is such an admirer of *Polaris* management methods that it has adopted a version of the Navy's PERT to prod its own program.



RADIO-FREQUENCY SHIELDING fence 65 feet high completely surrounds high-powered acquisition radar transmitter. Fence—to be covered with metal screen to shield personnel and equipment from potentially dangerous electromagnetic radiation —was designed after completion of an extensive survey of the radiation hazard by the office of the Army Surgeon General.

accomplish its objective—from acquisition to intercept—is only a few minutes. The complete operation must be almost totally automatic since there is no time for human operators to control the equipment, make decisions, and issue commands. Consequently, the system is built around computers which evaluate incoming information and make intelligent decisions based on this operation. It is built to operate "hands off" from detection to kill.

An operational *Zeus* installation, or defense center, will include acquisition, discrimination, target track, and missile track radars as well as the computer and missile battery control center. In operation, the acquisition radar will detect and acquire the incoming warhead. The discrimination radar will "study" the warhead and separate out decoys and other confusion devices. The target track radar will lock on the target and establish its trajectory. The target intercept computer, acting on the information received from the radar, will launch the *Zeus* missile and control its flight through the missile track radar. The *Zeus* nuclear payload will be detonated on computer command at the intercept point, to kill the enemy warhead.

• **Acquisition radar**—The *Zeus* acquisition radar (ZAR) represents the most significant advancement in the entire concept. If any one part of the system can be said to be the most important, the ZAR is undoubtedly the one.

To detect and acquire a target the size of an ICBM warhead traveling at speeds of five miles per second at ranges of 700-1000 miles is undeniably a problem of the first magnitude. In addition, the radar must be able to provide track information on a large number of targets simultaneously. And the time available to accomplish this function is somewhere in the neighborhood of only 20 seconds. The acquisition radar was number one on the list of things-that-couldn't-be-done.

Due to the high output powers necessary, the ZAR uses individual antennas 1000 feet apart to transmit and receive.

The transmitting antenna is a flat triangular arrangement of three arrays, each about 80 ft. long. It rotates 360 degrees in azimuth and is mounted atop the half-buried hangar-size transmitter. A circular radiation-shield fence surrounds the entire two-story transmitter installation. Actual output powers are classified but they are in the multi-megawatt range. (Cornell Aeronautical Lab, under ARGMA supervision, just recently built a 50-megawatt microwave radar for research into ICBM detection and tracking.)

The ZAR receiving antenna is a unique application of a Luneberg lens. It is an 80-ft.-diameter solid hemisphere made of plastic foam impregnated with light slivers of metal. The slivers are distributed in the plastic in a very exact composition to vary precisely the dielectric constant. The metal-impregnated plastic acts very much like an optical lens, concentrating the returned radar pulses on multiple receiver horns inside the 110-ft. covering radome. The received information yields range, elevation, and azimuth data on the incoming target.

The ZAR receiving antenna incorporates several unique innovations in antenna design—as well as pushing the state-of-the-art in pure mechanical construction.

The most complex problem was the precise distribution of metal in the plastic foam. The solution is looked upon as one of the most important in the R&D program. The plastic is formed in 18-in. cubes and the hemisphere constructed of these in much the same way that a solid igloo would be built. Forty-two box-car loads of the plastic are required for one antenna.

The support bearing for the 1000-ton antenna is one of the largest ever made. Thirty feet in diameter, the bearing has an accuracy tolerance of 0.0005 in.

The receiver uses a maser amplifier to give the system an extremely low overall noise figure (about 4°K).

• **Discrimination radar** — Development of the vital discrimination radar (DR) was another of the complicated problems besetting the *Zeus* team. In fact, the whole problem of discrimination is one not yet entirely solved and requiring a great deal of research in the future. Continuing inputs from the *Defender* program, including data from Army's DAMP (Down-range Antimissile Program) and PRESS (Pacific Range Electromagnetic Signature Study) are expected to shed further light on the problem. During the next year, ARGMA's schedule calls for an expansion of data from DAMP, collection of actual tracking data with *Zeus* radar, and the tracking of decoyed shots.

FIRST MODEL of Zeus target track radar is installed at Ascension Island for tests against nose cones fired down Atlantic Missile Range. Huge mount—which barely fits in C-133 transport—weighs tens of tons. Accuracy of mechanical components is extremely critical to match precision of overall system.

ARGMA's approach to the discrimination problem is not to depend on any one technique nor to apply any one technique at just one point. Many promising methods are now within the state of the art and others are expected to come along in the near future.

An Army spokesman recently said: "The art of discrimination today consists of a solid array of theories on a broad front—now we must collect the

TRANSMITTING ANTENNA of Zeus acquisition radar is as big as a baseball infield. Mounted on top of its transmitter, the antenna rotates at 10 rpm to sweep the sky for oncoming ICBM warheads. This installation at White Sands will be used in research and development system testing.

LEFT: *Developmental model of Nike-Zeus target intercept computer. System is a high-speed, general-purpose, digital computer with a large variable memory capacity.*

RIGHT: *Target intercept computer rear view shows arrangement of stacked C-planes and array of air-conditioning ducts.*

FAR RIGHT: *Guidance test console (at left) is shown during checkout of a guidance section before installation in third stage of Nike-Zeus.*

necessary tracking data using actual *Zeus* equipment rather than just laboratory synthesis."

Army stresses highly the joint efforts expended on the discrimination problem in cooperation with the Air Force. ARGMA maintains liaison officers at both Vandenberg AFB and AFBMD headquarters. The two services work together on decoys and discrimination, nose cone design and signatures, firing schedules for DAMP, and long-range cooperation of the *Zeus* radar on Ascension Island.

Army provides AF with signature data to help them in nose cone design. AF passes on to Army decoy development information and booster fragmentation data for radar tests. And, of course, both cooperate on firings of the AF *Atlas* in a double-barreled effort which serves to train AF crews as well as provide targets for *Zeus* tracking and intercept.

Details on the *Zeus* discrimination radar are pretty tightly bound up in security. Primary feature of the variable-beam antenna used is its great data-handling capacity. The transmitter uses a multi-megawatt klystron power amplifier tube developed specifically for *Zeus*.

• **Target track radar**—The needle-beamed target track radars (TTR) take over automatically once the target is located by the ZAR. They furnish continuous precise trajectory information to the computers to determine the intercept point.

The TTR uses a 25-ft.-Cassegranian reflector in a 40-ft. radome. Basic features of the radar are its range versus small target radar cross-section, very narrow beam, and extreme accuracy. Its huge mount weighs in the tens of tons and is reportedly the most precise ever produced. The *Zeus* TTR was used in the recent successful missile kills by the *Nike-Hercules*.

• **Missile track radar**—The missile track radar (MTR) tracks and guides the *Zeus* missile to the intercept point, and commands its destination. Tracking is achieved through a beacon in the third stage. Design of the MTR—described by ARGMA as "a relatively simple job"—is a direct outgrowth of the *Hercules* track radar.

• **Target intercept computer**—The brain connecting the flow of information to and from the radar complex monitoring an incoming ICBM and directing the defending *Nike-Zeus* is the target intercept computer (TIC).

Simply stated, its role is to solve the guidance and control problem for successful intercept of anything from a single attacking warhead to a salvo employing decoy tactics.

Western Electric and the Army believe that TIC will do the job. More importantly, its design is flexible enough to do it well into the future—as state of the art is advanced for AICBM's, ICBM nose cone design, and decoy techniques.

The computer is a high-speed digital system employing all the tricks of built-in reliability. A design goal of 0.01 failure per 1000 hours operation for high-speed switching transistors and deposited-carbon resistors gives an indication of the severe requirements to be met in fabrication.

In testing transistors during the extended reliability studies, over 160 million hours test time have been accumulated, during which there occurred a total of only 7 hours failure time.

• **Fabrication unique**—Over 90% of the computer system is comprised of one standardized electronic package. Called an "A-module," these cigarette-package-size units are assembled in horizontal racks designated "C-planes." These in turn are stacked and connected in drawers called "D-modules."

All electrical connections employed in the system are made using the "wire-wrap" technique to avoid solder connections. With over one-half-million A-modules used in a single system which requires more than 20 million connections, the wire-wrap method eliminates the danger of faulty connections and is applicable for automation.

The module assembly approach, too, lends itself to automated fabrication and inspection. Also, it later simplifies maintenance and unit replacement in the field.

The computer is capable of 200,000 arithmetic operations per second (roughly 20 times better than a standard high-speed business computer).

It employs a variable, permanent-memory device comprised of elements called "twistors." The twistor, which consists of tiny bar magnets and extremely fine wires wrapped with magnetic metal tape, is another recent Bell Labs development. Although new, its production already has been automated.

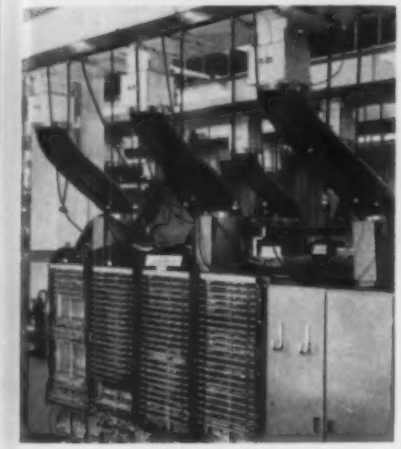
Acquisition of data from storage requires about 2.8 microseconds.

• **Radar/computer processes**—The guidance computation problem starts with ZAR when it detects and acquires probable targets. The radar outputs are fed into the detection data computer at a *Zeus* defense center.

A battery is assigned responsibility and first inputs are fed into its target intercept computer. The battery discrimination radar is engaged and the identification process begins.

Using a variable-beam antenna, the DR employs its long range, short pulse-width, and multiple-frequency transmitter to obtain a reflected identification of the approaching vehicles.

By extremely sophisticated processing, these data will be separated and



compared with all the known identification characteristics held in storage within the computer.

Discrimination, in over-simplified terms, can be compared to sorting apples. Radar information received from the target is shuffled down through various "screens" by the computer, sorting it out according to various programed parameters. Based on known characteristics of ICBM warheads, the incoming data are dumped into various trays and classified until, by a process of elimination, the real target is identified and the trash discarded.

It is the collection of this mass of meaningful signature characteristics that has received such a concentrated effort during the past two years from both the Army and the Air Force.

• **TTR and missiles assigned**—When an approaching vehicle is identified as a probable target, the computer assigns a target tracking radar, assigns particular *Zeus* missiles for a defensive salvo, and initiates missile warmup.

Reaction time is paramount at this point, for such vital components as the power supplies and gyros must be ready ahead of the launch order.

Technical Breakthroughs in Zeus Development

- Low-noise receiver
- CHIRP (Signal Compressor technique).
- Twistor (Computer permanent memory device).
- Super-power klystrons.
- Luneberg lens media.
- Production techniques for computer components (A1-modules and C-planes).
- Mass production of high-reliability transistors.

Data received from the TTR is then analyzed to compute the time of flight and determine *Zeus* initial intercept trajectory and burst point. These data are then fed from the computer to the missile tracking radar assigned to each *Zeus* missile.

The missile tracking data and *Zeus* guidance inputs are under continuous refinement. At the computed time, the launch order is generated by the computer and the salvo first-stage rocket engines ignited.

Principal intercept corrections, once the birds are in flight, are made just seconds before reaching the planned intercept point.

Missile arming and fuzing occurs only when a series of safety requirements have been met (altitude, speed, etc.).

Finally, the computer issues the burst order and then clears for the next defensive action.

• **Missileborne guidance**—One of the great advantages in any radio-command guidance system is relative simplicity of the missileborne guidance package. *Zeus* is no exception, although somewhat more flexible in its capability.

Electronics in the third stage is standard, consisting of the transponder or radar beacon, command receivers, gyro reference platform, control system, power supply, timers, and associated circuitry.

The reference platform is a fully gimballed system employing three 1-degree of freedom gyros.

Control by the missile tracking radar on the ground is accomplished by means of the transponder (for tracking) and the command receivers (for guidance orders).

Power for the third-stage electronics is from a battery pack. Hydraulic actuation for control of the four external vanes on the warhead is by a hot-gas turbine. This same system also controls the third-stage rockets for omnidirectional control in the extra-atmosphere.

No terminal homing is employed, because of the need for an ablative nose-cone during missile exit. Use of such a system might be desirable but is currently beyond the state of the art.

• **Manual override**—The entire *Nike-Zeus* weapon system is fully automatic, but human intervention is possible at any time.

At the battery control centers, consoles provide three-dimensional screen displays for monitoring defense operations. Here also is located a manual override whose use is discouraged but nevertheless is available when necessary.

Also located in battery control are extensive troubleshooting panels. These indicate maintenance status for all of the electronic equipment and indicate which particular rack and drawer is defective upon failure. Additional indicator lights on the equipment racks more precisely locate faulty units.

• **Automatic checkout** — Heart of the checkout system is Stromberg-Carlson's SCATE (M/R Sept. 21, 1959; p. 54). The automatic checkout system is a fully transistorized, high-speed system which uses Mylar punched tape for programing.

The equipment has been completely integrated with the ground and missile guidance system. It provides constant monitoring and scanning of sensitive test points, a go/no-go readout, visual and printed, and includes fault prediction analyses.

A supplement to the unit is an r-f test set used to test the missile-borne guidance package. It is remotely controlled from the master control panel at the battery control center. ■

NIKE-ZEUS

Speed-up Of Missile Output Would Be Simple

Douglas and Thiokol see no major difficulties in expansion; support equipment is also well advanced

by William J. Coughlin

THE LEAST COMPLICATED aspect of the *Nike-Zeus* development program is the missile itself.

Many production problems already have been solved at Douglas Aircraft Co., in turning out the several hundred missiles needed for the research and testing phases.

On the propulsion side, Thiokol jumped from a 3.5-in. scale motor to a full-scale *Zeus* booster without any intervening models—or trouble.

Douglas says that a step-up in production to the numbers currently being discussed would require only a slight expansion of facilities at the Torrance plant of the El Segundo Division.

"The problems, if any, are of the nature of trimming a resistor or beefing up a frame," says R. L. Johnson, chief engineer, Missile and Space Systems. "They are of the type that do not require drastic changes in design, production facilities or support equipment."

• **Tempered optimism**—Complexity of the *Nike-Zeus* system lies in its computers and radars, Johnson points out. Production of the missile can be increased to whatever numbers are desired well within the time span required to step up production of the electronic equipment.

"We also are further ahead with support equipment—launchers, shipping containers and test sets—than we were with *Nike-Ajax* and *Hercules* at this stage," Johnson adds. "We feel we know more about *Nike-Zeus* than we did on either of those."

This optimism is coupled with the caution that not all problems are solved yet—or even known.

Although 48 1/3-ft.-long *Nike-Zeus* is a fairly straightforward design, it does have some unusual features requiring production techniques which are pushing the state of the art.

These include:

–Insulation of the entire missile with exception of the booster. Application of this to the aluminum missile requires special tools and techniques.

–Motor case production from high-strength modified 4340 steel. Several years study have been necessary to develop the know-how and equipment for this.

–Use of large plastic nozzzles. In the case of the booster this means a 42-in. bell. At the time development of these was begun, the techniques required were well in advance of the technology.

Major design objectives were to hold down weight and size of the missile and to improve its flight time to target. Douglas engineers settled on aluminum shielded with ablative material, with high-strength steel for motor casings.

The booster, which has a burning time of 5 sec., is of conventional design with a plastic nozzle and aluminum fins. The sustainer likewise is of high-strength steel. The nozzle also is plastic and the aluminum fins are covered with ablative material.

• **Third "cousin"**—First two stages of *Nike-Zeus* have been deliberately kept simple, N. T. Weiler, chief project engineer, notes. All of the headaches have been saved for the third stage.

A spherical, third-stage solid-propellant motor provides forward thrust and out-of-atmosphere control through the missile's cannard-design "jetavator" control system. Control within the atmosphere is aerodynamic. The third-stage engine is not used to gain velocity —as in a conventional ballistic missile —but primarily for control.

"It's a first cousin to a third stage but you can confuse people by use of the term," Weiler warns. For intercepts within the atmosphere the final stage does not separate from the sustainer.

Base section of the "jethead," or third stage, contains the guidance system and the inert quick-activating battery airborne power supply. Small external fairings in this area are antennas.

Forward of the guidance system is

(continued on page 41)

CYLINDRICAL CHAMBER for the Zeus third stage guidance propulsion unit has its loading area diameter checked by a Douglas Aircraft Co. technician.

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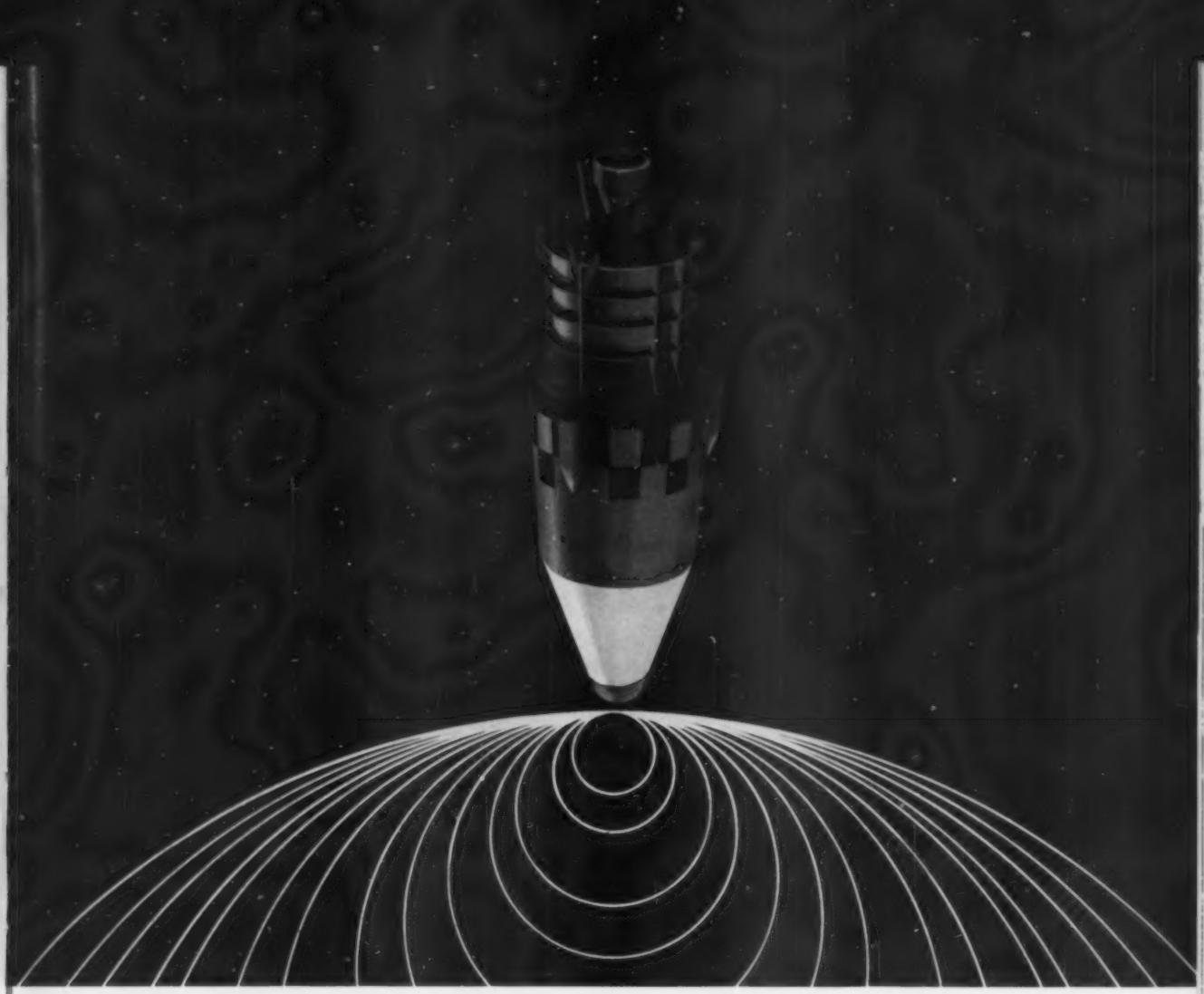

"MIDAS" REPORTS

through communications equipment by Philco

MIDAS II, the experimental "sentry in space," is the forerunner of a series of satellites that will detect the launching of ballistic missiles anywhere on earth and instantly relay the warning. Its entire communications system was designed and produced by Philco's Western Development Laboratories for the U.S. Air Force, as associate contractor with Lockheed.

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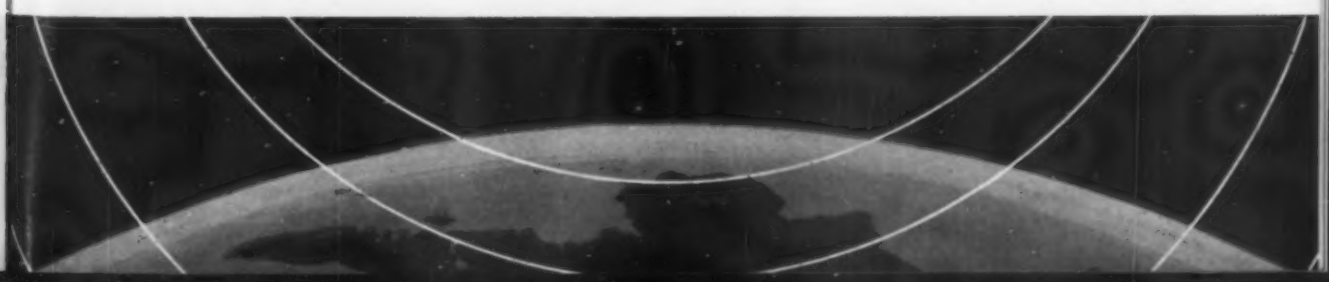

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The incredible complexity of the BMEWS network and its vital mission in continental defense demand the ultimate in system reliability. Through unique and highly advanced developments by RCA this standard is being achieved.

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Around-the-clock operation of this RCA equipment enables BMEWS to meet its over-all operability goal with negligible downtime, thus keeping BMEWS on the air!

The Central Automatic Monitoring Console displays the status of the entire site, and displays equipment degradation prior to failure.

The Checkout Data Processor generates simulated missile attacks and evaluates the BMEWS response to the simulation.

The Automatic Monitoring Console displays degradation and the location of degraded equipment.

RCA Checkout and Automatic Monitoring (CAM) Equipment has greatly enhanced the reliability of complex ground environment systems. Adaptable for use in systems already completed, and as an integration tool for systems currently being implemented, CAM equipment is available for all complex commercial, military, and government systems. For a description of the RCA Checkout and Automatic Monitoring Equipment, write to: RCA Major Defense Systems, **Defense Electronic Products,** CAM 127-204, Moorestown, New Jersey.

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Megawatts for NIKE ZEUS...

With a booster of over 450,000 pounds of thrust, NIKE ZEUS will need still another form of power to fulfill its anti-missile assignment. This other power is in millions of watts – energy for the system's extended range target tracking and discrimination radar transmitters.

Developed for the Army by Sperry out of its long experience in high power radars, and employing giant-wattage Sperry klystron tubes, the target tracking transmitters will permit greater-than-ever capability for radar tracking of "hostile" targets. The discrimination radar is designed to classify targets according to the nature of the threat.

NIKE ZEUS – the nation's only anti-missile missile system now in the advanced development stage – is undergoing R&D and pre-production programming under the Army Rocket and Guided Missile Agency (ARGMA) cognizance, with Western Electric as prime contractor and Bell Laboratories responsible for the overall system. It is the only missile system now in development for intercepting ICBM's . . . to defend our cities and defense sites.

SPERRY

SURFACE ARMAMENT DIVISION, *SPERRY GYROSCOPE COMPANY – DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, N.Y.*

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(Continued from page 36)

the hydraulic auxiliary power unit—an AiResearch solid propellant gas generator. Above the APU is the third-stage engine and then the hydraulic control system for the fins. Final item, of course, is the nuclear warhead.

• **Straightforward production**—Engine cases are fabricated at the Torrance facility from steel sheet. This is inspected ultrasonically and then rolled on conventional equipment into half cylinders. These are trimmed, joined and welded longitudinally with an automatic inert gas shield arc.

Domes are conventionally deep-drawn. Douglas is experimenting with explosive forming for final configuring, not only for domes but for spherical motor case in the jethead. The domes are formed with an opening for the igniter boss, with some machining of this and the attach points. Cones for nozzle attachment at the opposite end of the motor case are machined from a forging.

Douglas has developed a unique nozzle attachment said to be about half the weight of a conventional bolt joint. This involves use of flexible steel, with no stress on the nozzle attach points until actual firing of the motor.

Before the dome and nozzle are attached to the case by roll seam welding, the case goes into a sizing machine. Here, a series of segmented mandrels expand it to given diameter.

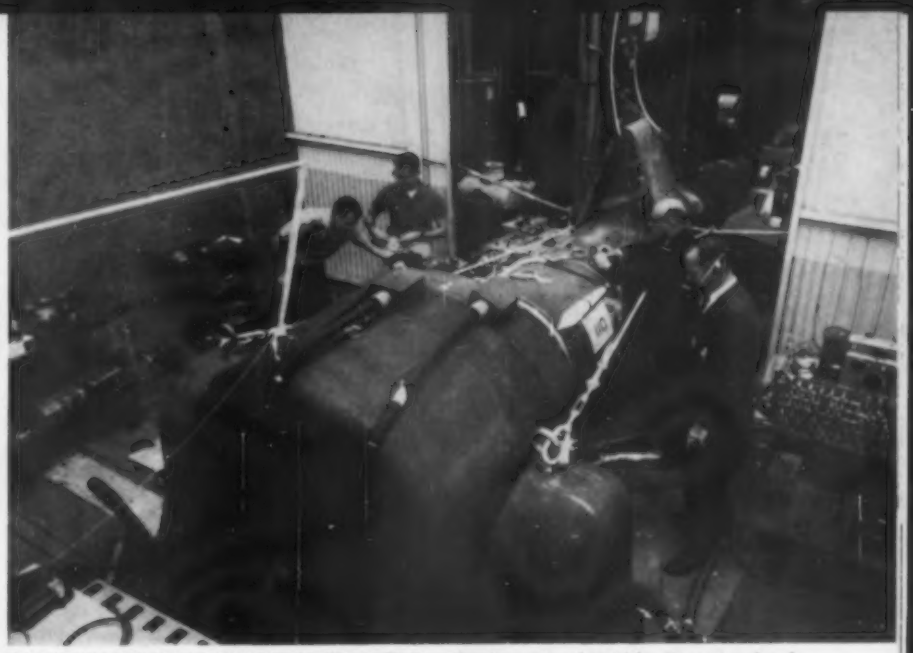
The igniter boss, machined from a forging, is welded to the dome; the case is heat-treated in a vertical gantry-type cylinder. This is a conventional quench and draw process under closely controlled conditions.

Final trimming on the igniter boss and nozzle attach joints is done with the case in a large lathe. Aluminum alloy frames for attachment of adjacent missile sections then are lock-bolted on.

Interior insulation of the sustainer is cured in place under heat and pressure after being laid in at the ends of the cases. Interior booster insulation is done at Thiokol.

Douglas reports actual proof testing of these cases to 237,000 psi. Two were cycled at this figure for over 100 cycles with no failure. With firing pressures of 217,000 psi, Douglas engineers are hopeful of going to a lighter weight and less expensive case material.

• **Propulsion breakout**—For an interim period, Grand Central Rocket is providing propellant for the sustainer and third stage and Thiokol for the booster. In mid-year, Thiokol is to be phased in on the other two stages. During the research and development period, cases are shipped to Thiokol for loading. Production loading will be at the Charlotte, N.C., arsenal.



MASSIVE SHAKE TABLE simulates flight vibrations in the Nike-Zeus jet head.

The third stage is manufactured in the standard airframe approach with some formed and some machined frames covered by 24ST aluminum alloy welded into a cylinder. This stage is manufactured in four sections, for ease of access to interior equipment. The jethead has a minimum of access panels due to high temperature encountered in flight.

Details of plastic facilities used for turning out the lightweight nozzles are classified; Douglas feels that the drastic reduction in weight over equivalent steel nozzles—some 50%—amounts to a breakthrough. But the method used is known to involve helical winding of fiberglass filaments onto the nozzles after application of glass cloth.

A. J. Carah, *Nike-Zeus* design engineer, says the Torrance facility as now equipped could not quite meet production numbers presently under discussion. A new heat treat furnace and additional welding equipment would be among the items required.

"But we could start production right now and build up to a fairly substantial rate quickly," he asserts.

Production of the third stage and final assembly of the production missile will be at the Charlotte arsenal, where *Nike-Zeus* will be checked out as an integrated unit and then shipped to site or depot as required. ¤

FINISHED MOTOR CASES for Nike-Zeus booster stage are stored for future use.

Missile Has Special Protective 'Skin'

by Dr. R. M. Wood and T. J. Ashley*

EPOXY GAP FILLER is applied to longitudinal crevice between insulative sheets on Nike-Zeus section.

FILLED AREAS are blended with surrounding coating by sanding after heat cure. Base is Shell's Epon 828 resin.

A UNIQUE FEATURE of the production of *Nike-Zeus* was the development of the insulative shield which covers the missile's entire metal exterior—a coating made necessary by the extreme acceleration *Zeus* must achieve immediately after lift-off in order to meet its target on schedule.

Flat sheets or molded shapes of phenolic/nylon are bonded to all surfaces of small angle of attack. Phenolic/Refrasil covers leading edges and other areas subject to high aerodynamic shear and pressure forces.

The severe aerodynamic heating encountered during the booster stage of flight requires that all gaps, joints, holes and surface imperfections in the insulation must be repaired or thermally protected to prevent damage to the missile structure beneath.

Gaps are inevitable, in spite of the close-fitting sheets. Normal manufacturing tolerances in the fabrication of flat and molded parts also create difficulties.

• **Perfection a necessity**—In some areas of the missile the heat flux rate varies greatly with geometry. Weight can be cut significantly by permitting the insulation thickness to vary with the geometry and heat flux rate. For these areas, parts are molded to contour. Butting molded parts to flat sheets invariably produces gaps which are as deep as the coating and up to 1/8-in. wide.

Holes also are a problem. After the missile structure has been produced, technicians must be provided access to to the interior of the missile to make adjustments and to install various pieces of equipment and telemetry hardware. Access openings are provided in the skin to permit entry. When all work finally is completed, the openings are sealed by means of panel doors which are bolted in place. Bolt holes in the insulation are as large as the boltheads, and may be as deep as the protective coating. Holes must be filled flush with the coating.

In addition to gaps and holes, there is also the possibility that the coating may be gouged or scratched as a result of handling while the missile is in transit to the launching pad. Damages of any kind to the coating must be repaired before the countdown button is pushed.

Considering the insulative requirements of the protective coating, the material selected to fill gaps and holes has to perform as well or better than the coating itself. During flight the outer surface of the insulative material will be heated to an ablation temperature. At this temperature it begins to decompose and the surface regresses. At no time should the gap filling compound deteriorate faster than the coating, nor debond; otherwise, aerodynamic heating could affect the metal skin of the missile at those points.

Normally, it is not required that the gap filler be the same density as the primary thermal insulating or ablating materials. This is because the gaps and bolt holes represent a relatively small area over the missile.

Even if the density of the filler were quite high, it would not represent a critical weight factor because only small amounts of materials are applied.

The gap and hole filler used on the *Nike-Zeus* is a heat-resistant, classified formulation developed in the Douglas Materials Research and Process Engineering Laboratories. It is a composition based on Shell Chemical Co. Epon® 828 resin and cured with diethylenetriamine. It has low shrinkage, good mechanical strength and excellent adhesion to metals and reinforced plastics. While good room-temperature cures can be achieved, Douglas prefers to apply heat to speed curing—especially in the field. Large furnaces are employed in-plant; heat lamps are used in the field. The epoxy material is easy to prepare and can be applied with relatively simple equipment.

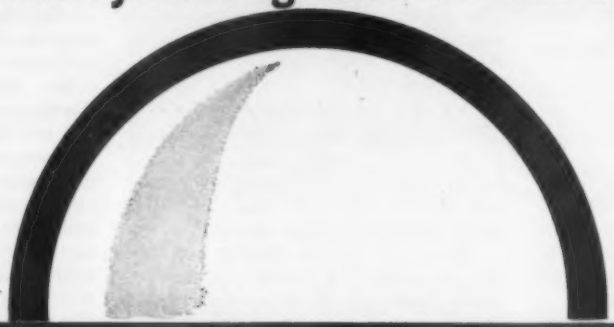
• **Caulking Zeus**—Gaps in the protective coating are filled with a pneumatic gun where two pieces butt together, and by hand where complex molded parts are faired into sheet material. The epoxy gap filler is prepared in both cases by mixing only the amount of resin and curing agent that can be used within a certain period.

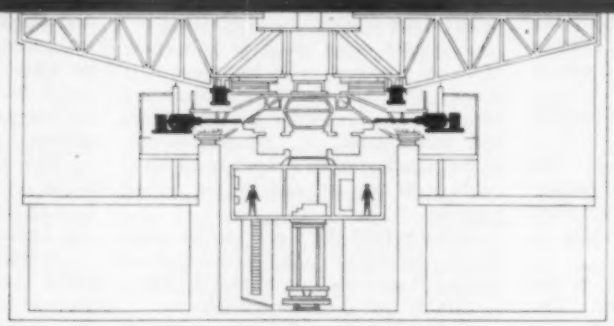
For gun applications, the mixture is loaded into a Teflon container which is reusable because the resin will not adhere to this plastic unless the latter is especially treated. The container is then placed in a metal barrel which is attached to the trigger mechanism. After the Teflon filler tip is screwed into the container, the gun is ready for use.

The epoxy filler is pumped out of the tip, the end of which is fitted with a washer to smooth the resin as it emerges. When the resin has cured, the filled areas are sanded to blend with the surrounding protective coating. Holes and surface imperfections are hand-filled with the epoxy material and sanded smooth after cure. ⌗

* *Chief, Thermodynamics and Nuclear Science Section, and member, Missile Experimental Thermodnamics Group, respectively, Douglas Aircraft Company, Inc.*

Radar Antenna Drive by Westinghouse for Nike-Zeus* on Kwajalein





On some undisclosed date in the future, the free world's only anti-ICBM missile system now in development—the U. S. Army's Nike-Zeus—will face another critical test.

A Nike-Zeus complex located on tiny Kwajalein Atoll in the Pacific must detect, track and kill oncoming ICBM's. USAF crews will fire the would-be enemy (Atlas) missiles from Vandenberg AFB.

One of the key performers in the spectacular intercept will be 1250 tons of Acquisition Radar standing several stories high. Westinghouse is supplying the antenna drive motors and controls and a 30′ dia. hydrodynamic thrust bearing under subcontract to Goodyear Aircraft Corp. Westinghouse is one of the few companies, anywhere, that could manufacture a bearing of this size.

Imagine the demand for precision accuracy and delicate maneuvering to get the jump on an ICBM. Tolerances for the bearing were extremely exacting: sectors of the 30′ diameter segmented bearing must be held flat within .0005″.

Westinghouse can supply complete drive systems and mechanical components for just about any type of radar antenna. From a simple AC drive for continuous scanning on up to complex solar exploration radar. We provide the complete package: motors, gearing, controls, thrust bearings, etc.

So relay your requirements to Westinghouse . . . via the local Westinghouse sales engineer or by writing direct: Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse. J-92508

*Prime Contractor: Western Electric Co./Bell Telephone Laboratories.

Westinghouse

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'The Sun Never Sets' on Zeus Testing

Army insists on most rigid possible test program, but no frills; $90 million so far for brick and mortar

by John F. Judge

NIKE-ZEUS testing sites are scattered halfway around the globe. Facilities are in operation or under construction to check out every aspect of the complex antimissile missile system.

The massive test program is designed to complete *Zeus* system development in the shortest possible time. Simultaneous testing of various components is under way from Ascension Island in the South Atlantic to Kwajalein Atoll in the Pacific's Marshall Islands.

Approximately $90 million has been spent to date for brick-and-mortar type construction alone at all test sites. The Army's Corps of Engineers is handling the construction job.

No frills have been added to the task of checking out the system. "The Army is real hard-nosed about gold plate," says one contractor. Each site was chosen with care. For example, 18 locations in the Atlantic and 33 in the Pacific were considered before Kwajalein was picked.

ZEUS being readied for test firing.

• **Checkout problems**—*Nike-Zeus* differs from the rest of the *Nike* family in that the system must "see" the enemy object much farther away and with greater accuracy. And this object is traveling at ballistic speeds.

To compound the testing problem, *Zeus* is designed to combat future warheads including those re-entering at speeds greater than Mach 15. A wide spectrum of targets are incorporated in the *Zeus* design.

Ultimate proof of *Zeus* will come in actual engagement of incoming warheads. The Air Force is cooperating closely with the Army in the design and construction of "special" targets to be launched with *Atlases* from Vandenberg at the tail end of the testing program.

This entails the *Zeus* system actually "defending" Kwajalein Atoll against America's operational ICBM's.

Major test facilities include:

• **Bell Telephone Laboratory, Whippany, N.J.**—Computers simulate "flying" the birds in the "Blue Room"—named after the color of the walls. BTL is equipped with a large radar complex. Scientists in the Basic Systems Design Group have a backyard capability to checkout the complex gear to determine if it lives up to design predictions. A *Zeus* Target Intercept Computer (TIC) is currently being installed.

Backed by years of similar effort in the overall *Nike* programs, the Whippany complex has saved the *Zeus* project "countless" dollars in the live firing tests alone by investigating every conceivable aspect before actual ignition. Such simulation flights checked out very closely with live test shots in the *Hercules* program.

ARGMA considers Bell's work in this area as the most important single aspect of the entire test program.

• **Ascension Island**—Ballistic missiles fired down the Atlantic Missile Range from Cape Canaveral soon will be tracked by highly accurate radar equipment. A *Zeus* Target Track Radar (TTR) has been installed and energized. Its dish antenna measures 25 ft. across and a plastic radome houses both it and its 200,000-lb. mount.

Information on the radar characteristics of incoming warheads will be recorded on magnetic tape by a computer. Data from ARPA's DAMP (Downrange Antimissile Program) ship and two Air Force instrumentation vessels will supplement the TTR acquired information. The *Zeus* TTR data will be fed into computers at White Sands and Point Mugu to check on the accuracy and reaction time of the *Zeus* system. The tapes will simulate an ICBM target, providing the *Zeus* missile with the location of the warhead and intercept points. At White Sands and Mugu, *Zeus* missiles will be fired and recording instruments will indicate its success in intercepting the "ghost" target based on information fed into the target intercept computer by the Ascension Island tapes.

The TTR at Ascension is expected to be operational by mid-1961. Its recorded data also will be given to the Air Force.

• **White Sands, N.M.**—Partly finished, this *Zeus* facility includes a complete radar complex, launch cells, battery control and necessary data processing equipment. The range has a size limitation allowing only the firing of the first two stages of *Zeus*. Thus the testing of the missile up to and including second-stage firing and control generally defines the range's mission.

Firings are conducted over White Sands Extension, a 40-by-40-mile section leased by the Army. But the tests may be run only at specific times—never during the lambing season. The handful of residents living in the area insisted upon this provision in their lease to the Government.

Designated *Highball I, II,* and *III,* these new tests here will consist of radar checkout objects boosted to altitudes over 100,000 ft. by *Asp-Apache* research rockets. The series was developed by the Physical Sciences Laboratory, New Mexico State University.

Payloads will be parachutes, balloons and other items designed to check out radar equipment with respect to target cross-section, multiple targets and the like. A B-47 will be tracked to trim the radar.

• **Point Mugu, Calif.**—This year all three stages of *Zeus* will be fired for the first time down the Pacific Missile

ng Facilities

Range. Two launch sites, Missile Tracking Radar, Target Intercept Computer, associated data processing equipment and control facilities have been installed. The facility is purposely being kept as austere as possible, utilizing all available existing buildings and equipment.

• **Kwajalein Atoll**—Showdown tests of the *Zeus* system will take place over this tiny Pacific islet. *Zeus* missiles will be fired at re-entering warheads launched from Vandenberg AFB. Firings are expected to commence within 14 months.

The antimissile system will face two categories of targets: regular warheads and special nose cones developed specifically for *Zeus* tests. Equipment is now being installed to test out all the items in the *Zeus* system.

Every test at Kwajalein will be a complete system test. Facilities include telemetry sites on the neighboring islands of Ennylabegan, Gugegwe and Roi-Namur. A communications repeater station at Eniwetak and a boresight tower at Ennylegaret complete the ground stations.

KWAJALEIN ZAR RECEIVING ANTENNA (left) partially surrounded by ground plane structure. At right, transmitter and triangular antenna; center, radar power plant.

During the Pacific tests, any modifications or fixes will be carried out at White Sands or Point Mugu instead of at the atoll. The reasoning behind this move is aimed at keeping the personnel at Kwajalein to a minimum.

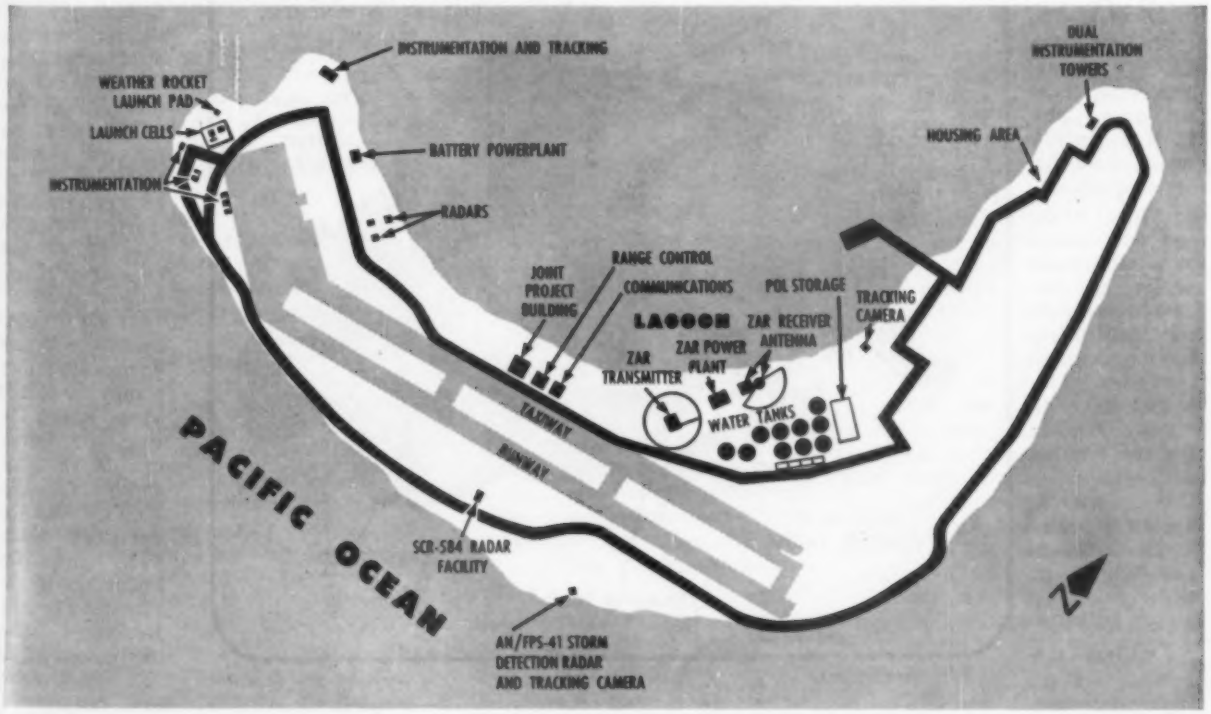
Radar trim will involve B-47 flights, similar to those at White Sands. For Kwajalein tests, an advanced series of *Highball* firings will be undertaken at Roi-Namur. A *Nike-Ajax* booster will be added to the original *Highball* propulsion system to checkout radar and intercept capabilities of the *Zeus* system. Called *Speedball,* this series will reach altitudes in excess of 100 miles. Eventually, *Hercules* missiles will be involved in this aspect of the program.

All of the *Atlas* warheads fired will be part of regular SAC training exercises with ICBM's. The "special" warheads will be designed specifically to confuse *Zeus* or present it with multiple targets and decoys.

The Kwajalein tests are expected to be overwhelming proof of the *Zeus* capability. Various parameters of targets and intercept geometry will be randomized with actual firings and interpolated Blue Room data.

Zeus was designed from the beginning to afford a positive defense against the enemy ICBM's of the next 10 years. Accordingly, the Army wants the toughest tests current U.S. missile technology has to offer. ⌗

KWAJALEIN—Showdown Test Site . . .



NIKE-ZEUS

How Components Makers Met Demands

Case histories of AiResearch's development of APU and Western Gear's work on system's radar antenna components

THE PRECISION end performance required of Nike-Zeus imposes severe requirements upon the program's subcontractors.

To gain some idea of how these demands are being met, MISSILES AND ROCKETS *went to manufacturers of two major components in the Nike-Zeus system—The Garrett Corp.'s AiResearch Manufacturing Division, Los Angeles, a subcontractor for an important airborne component; and Western Gear Corp., Lynwood, Calif., subcontractor for ground system components.*

Their experiences, outlined in the accompanying article, typify those of many Zeus suppliers.

by Richard van Osten

COMPLETELY NEW PROBLEMS faced The Garrett Corp.'s AiResearch Manufacturing Division three years ago when it won the subcontract for the *Nike-Zeus* hydraulic auxiliary power unit (APU).

Similarly unprecedented problems were encountered by Western Gear Corp., Lynwood, Calif., when it set about filling its subcontracts for radar antenna components for the *Zeus* system.

In both cases, the critical requirements of the unique anti-ICBM missile system were met or exceeded.

When it began development of its APU, under a Douglas Aircraft sub-contract, AiResearch had the advantage of prior APU work for the *Nike - Hercules.* But the Los Angeles firm found that it was up against problems which couldn't be answered on the basis of previous experience.

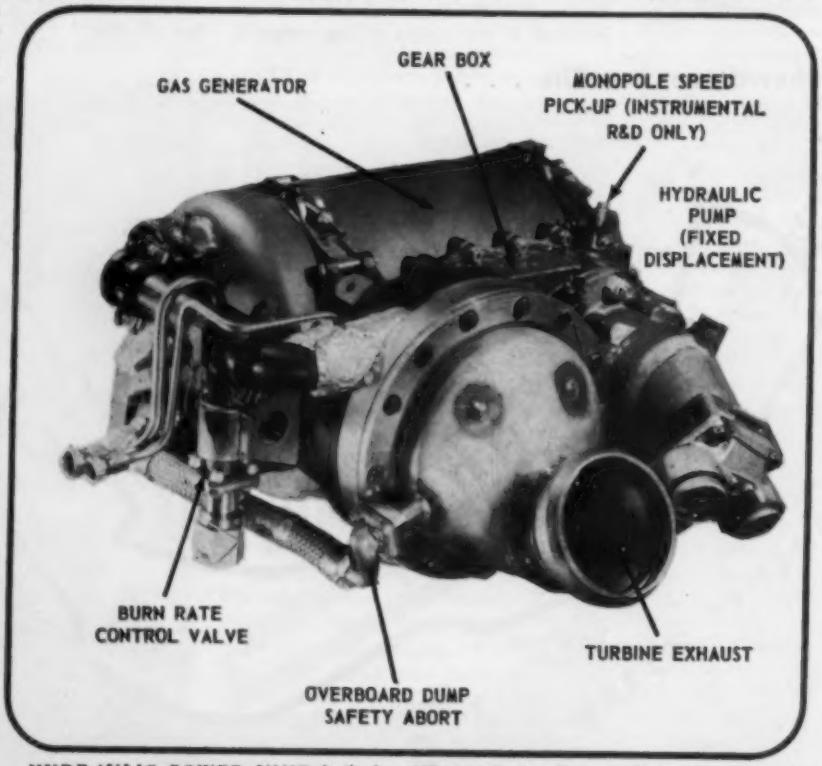
• Clean propellants — One was the development of a completely new solid propellant for the APU's gas generator. Most propellant research has centered on the propulsion system, with little attention to specialized, super-clean-burning mixes for APU turbine applications. The system is now using a nitrate-base propellant developed by Olin Mathieson Chemical specifically for the *Zeus APU.*

The propellant did not exist when the program started, but was created to AiResearch specifications by OMC to meet requirements of temperature, burn rate, stability in storage and reliability. The APU operates throughout all *Zeus* flight stages.

• Pushing the art—Another problem was design and development of the APU turbine. The turbine now being used in the unit turns at 78,500 rpm, compared to 50,000 rpm in the *Hercules* APU, and has a top speed of approximately 1590 feet per second. The unit is also designed to withstand a 50% overspeed condition. AiResearch claims the 50% operating efficiency makes it one of the most efficient turbines ever developed.

Turbine blades and wheel are integral. Because of the very small clearance between the blades, it was not possible to use a conventional machine cutting method. AiResearch has used several approaches, but the current approach, electrical-type metal removal, is the Elox process with Anodcut as an alternate. So far, the results have been very good despite close spacing of the thin blades and the 2000°F impinging gases.

The APU drives a Vickers pump, but other pumps produced by the Kellog Division of American Brake Shoe and N.Y. Air Brake will be evaluated. Additional propellant evaluation is anticipated also on a Rocketdyne solid mix developed at its McGregor, Tex., facility.



HYDRAULIC POWER UNIT built by AiResearch for Zeus includes gas generator assembly (in rear), turbine exhaust (front center), pump (lower right).

The APU has a torque-matching system based upon the high-performance axial turbine's characteristic sloping torque performance curve, where stall torque is greater than rated speed torque and varies between these two points for a constant input gas hp. If a turbine is operating at design speed and load torque, and the load torque is increased, turbine speed will reduce to the point where a new equilibrium condition is established with the higher torque available at the reduced speed.

These parameters may be replaced with pump pressure vs. pump flow, because capacity of a fixed displacement hydraulic pump is directly proportional to turbine speed and the torque required to drive the pump is directly proportional to pump discharge pressure.

In the *Zeus* APU, the design point in gallons per minute (gpm) corresponds to a turbine speed of 78,500 rpm at a pump volumetric efficiency of 96%, and turbine torque at that point corresponds to a pump differential pressure of 3000+ psi. Pump discharge goes directly to an accumulator having an air precharge pressure of 2200±100 psig prior to system start. Accumulator output is directed to the missile system through a regulator valve which maintains missile system pressure between 2700-3200 psig.

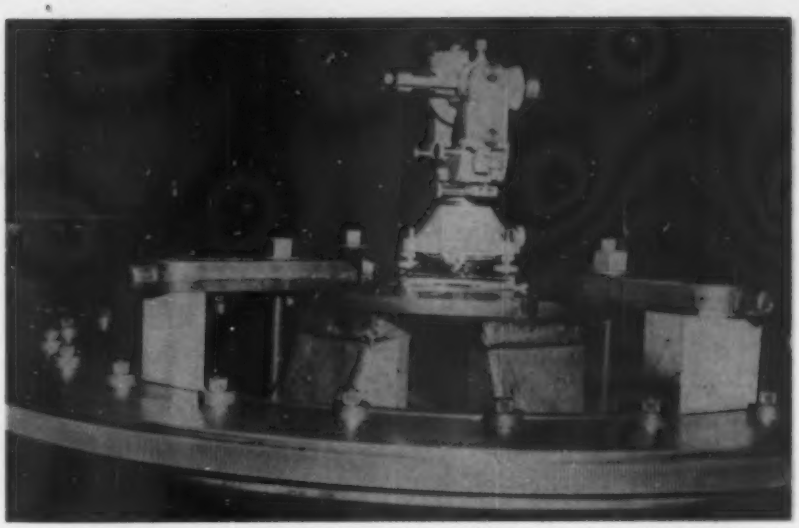
If missile flow demand drops to servo system leakage only, momentary excess output from the pump is prevented from damaging the system by use of a hydraulic relief valve with a cracking pressure of 4000+psi. Bypass flow is returned to the low-pressure reservoir.

The high-pressure accumulator is specifically designed and sized to match turbine and pump characteristics and compensate for turbine system inertia.

The low-pressue hydraulic (bootstrap) reservoir has sufficient oil capacity to fully charge the high-pressure accumulator to meet maximum missile surge requirements. It also provides adequate heat sink capacity to limit fluid operating temperature to 200°F at the end of the operating cycle. A differential area piston in the reservoir provides proper inlet pressure to the hydraulic pump.

Variations in gas generator output are most significant in the *Zeus* APU and must be compensated to make the system workable. To handle this problem, a burn rate control is incorporated to enable adequate matching of input and output torques.

The burn rate control uses basic characteristics of a solid-propellant gas generator. Specifically, if combustion pressure is increased, burning rate will increase and increase the flow rate.



WILD T-3 THEODOLITE mounted on hobber table was used by Western Gear to check index accuracy of the precision gear used on a Zeus radar antenna.

• **Challenge to Western**—Western Gear Corp. is subcontractor to both Goodyear and Continental Can for radar antenna components. The company supplies components for the *Zeus* Decoy Discrimination Radar (DDR) and Acquisition Radar (AR) to Goodyear and Target Track Radar (TTR) components to Continental Can.

An extremely critical component in these three antenna systems is the azimuth bearing assembly which carries loads and stresses between the rotating and pedestal sections of the antennas. The bearing is identical in both DDR and TTR antennas.

The bearing assembly consists of a bearing subassembly and a ring gear for antenna position data pickoff. Overall diameter of the assembly is approximately 56 in. Inside diameter of the bearing's outer race is 45 in. The ring gear on the assembly's perimeter has 1344 teeth.

Specifications called for accuracies on the order of 3.4 sec. of arc in angular accuracy between any one gear tooth to any other tooth on the ring.

Other requirements demanded that bearing race radial clearances not exceed 0.0002 in. Overall dimensional tolerances across the assembly's diameter were limited to a very few ten-thousandths of an inch. Specifications required also that the bearing's inner race be capable of being turned over without disturbing tolerances. This minimizes field maintenance problems in bearing replacement.

When Bell Telephone Laboratories first set forth overall requirements for the systems and components, BTL was not certain the needs could be met. Neither was Western Gear, but it was willing to try.

• **Exotic gear checkout**—After deciding the job could be done with existing equipment, the company was faced with the problem of how to prove it had met specifications. In searching for proof techniques, it was determined that an adaptation of methods used by machine tool manufacturers could be used.

This required construction of an optical metrology laboratory equipped with instrumentation rarely, if ever, found in gear inspection techniques. The laboratory also required strict environmental controls and has been designed to hold temperatures to within 1°F.

The critical azimuth bearing assembly is temperature-soaked in the laboratory prior to inspection. Then an instrumentation combination of a Wild T-3 theodolite and Leitz autocollimating equipment is used to determine if the assembly meets specifications. There has been little difficulty with this method, and the company says its rejection rate is almost zero.

A considerable amount of hand assembly is required for the bearing. All rollers in the bearing assembly are "hand-selected" and constantly compared against a master set to determine deviations from the standard and feed in any tolerance corrections required.

The azimuth bearing is one of the most precise units of its type ever developed, a good example of how *Zeus* requirements have pushed the state of the art in a number of technologies. Western Gear's solution is not unique, but it emphasizes that solutions are available to many problems in advanced design and production although they may come from an "outside" source. ⌗

When the first *line of defense* is *the only line of defense...* *Ultra Reliability* is Crucial!

There is only one anti-ICBM system under advance development in the free world—the U.S. Army's NIKE ZEUS. Once an enemy missile is detected, only minutes remain in which to intercept and destroy it. A Target Intercept Computer developed and produced by Remington Rand Univac solves launching time and predicts the time and point of intercept. At the precise moment, T.I.C. commands the firing of the NIKE ZEUS missile and issues the necessary steering orders to guide it to the target.

The NIKE ZEUS guidance system, produced in cooperation with Bell Telephone Laboratories and the Western Electric Company, demanded—and received—*the fastest, most reliable ground guidance computer yet built with a design goal of 600 operational hours* without component failure. The first of several Target Intercept Computers has been delivered on schedule to the White Sands Missile Range. Experience to date indicates that design requirements have been more than adequately met.

A *permanent twistor memory* and a ferrite core scratch pad memory are vital to reliability, assuring continuous operation until an attacking missile is intercepted and destroyed. Decisions are made in *microseconds*. Built-in error detection circuitry and unique modular construction have resulted in nearly *automatic maintenance*.

Univac's NIKE ZEUS Target Intercept Computer meets new standards of design and capability, and the most crucial test of front line defense—reliability.

UNIVAC®

CAPABILITY-INGENUITY-RELIABILITY for Business, Industry and Defense at REMINGTON RAND UNIVAC

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CONSTRUCTION of Zeus receiver enclosure and transmitter at Kwajalein Atoll.

NIKE-ZEUS

Bases Would be Many and Sprawling

Site on Kwajalein will be operational prototype if production begins now; 'brick and mortar' takes 16 months

DEPLOYMENT OF *NIKE-ZEUS* would involve a lot of real estate.

The system is huge.

"If you think the bullet is big," says one program engineer, "wait'll you see the gun."

Each defense center with its numerous separate missile-launching batteries would be situated on vast tracts of land. Studies show a typical battery of 24 underground *Zeuses* encompassing up to 125 acres—enough room for three Pentagon buildings and plenty of parking space. A comparable stretch of land would be needed to accommodate the giant acquisition radar, transmitter and power plant of a defense center.

Herein lies a problem. Many batteries designed to protect cities presumably would be located in heavily populated areas. Some skeptics believe it may take a year or more just to acquire some of the land.

But the Army's Corps of Engineers, which would run the construction program, feels more optimistic. The Corps believes that once given a go-ahead they can get the land and complete the "brick and mortar" phase of construction—all within 16 months.

The Corps, however, also is realistic. To avoid lengthy condemnation proceedings, officials are looking over available government-owned land. It may be practical in some areas to utilize existing *Nike-Hercules* sites, or to "satellite" batteries around military installations.

To defend Washington, for example, Army's Ft. Meade, Md., could be used as a base for logistic support and for housing personnel. Perhaps a defense center or some of the batteries could be built on the fort's grounds, thus holding down the amount of new land to be acquired.

• **Changing plans**—Today, plans for deploying *Zeus* are still fluctuating rather widely. They are subject to the many variables being pumped through computers, in search of answers to how much money will buy how much protection. All of these plans are classified. And, because it will be possible to set up *Zeus* in a variety of combinations—with one or many batteries operating off a single defense center—officials are reluctant to give cost estimates on even a single basic unit.

One battery, admits one official, probably will cost "quite a bit more" than a soft *Atlas* base, which bears a $40-million-to-$50-million pricetag.

Perhaps a better guide is the R&D installation now approaching 60% completion on Kwajalein Atoll. This facility—including a complete defense center and a battery of four missiles—is expected to cost $75 million. (However, this figure is inflated by an overseas construction cost index of 2.00 to 3.00, which would bring the cost in stateside dollars to $52.5-60 million.)

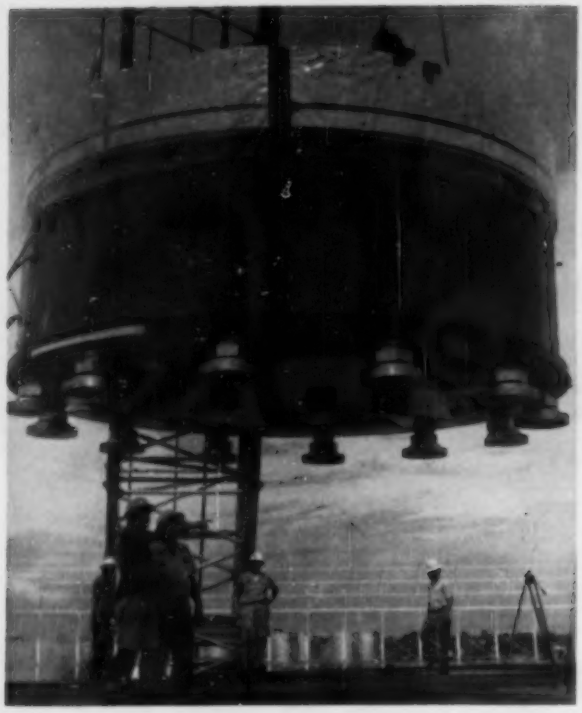
Should *Zeus* be committed to production now, the Kwajalein installation would become the prototype for tactical units. Base design—drawn from experience in building R&D installations—already is well advanced, so that the Corps can begin construction whenever it is asked.

• **Simple design**—No great base construction problems are foreseen now—since most of the structures are fairly straightforward in design. The missile, moreover, is solid-fueled, eliminating the intricate fueling systems which created so many headaches in the building of ICBM bases.

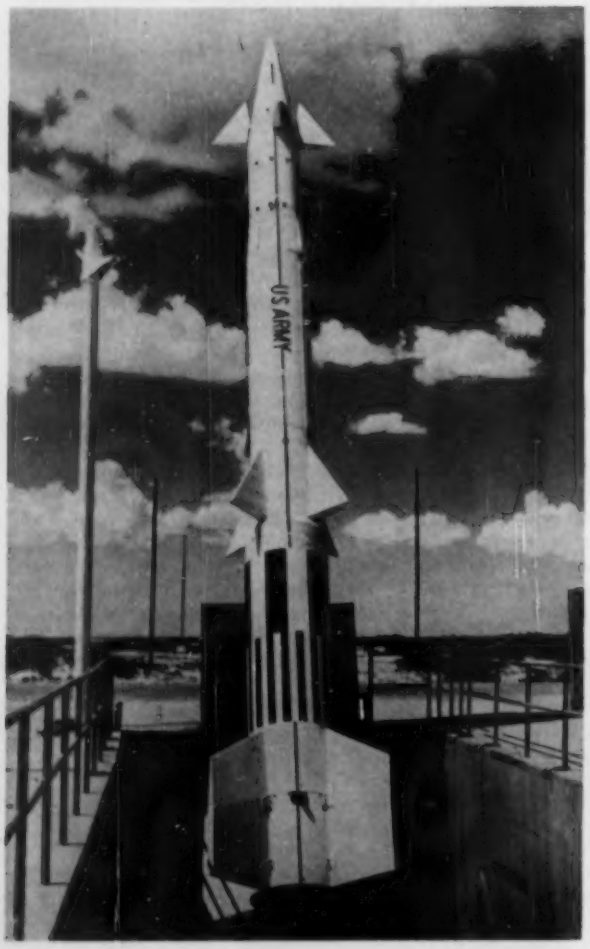
One difficulty lies in providing stable foundations for the huge radars, which impose rather impressive dynamic loads. Care has been taken to design away from harmonic effects and those caused by natural vibrations of the earth.

Safety has been another consideration. During the R&D program some launch facilities were made "over-safe," the Corps has found, simply because there was no previous experience in handling a bird with *Zeus*' high-thrust booster.

The first R&D launcher was an open reinforced concrete structure about 40 ft. deep that allowed exhaust gases to



FIRST piece of Zeus operational equipment to be installed on Kwajalein. (Atop ZAR Trans. Bldg.) GAC employees in foreground and Capt. Kleis, the ARGMA PFO exec., in background.



EARLY R&D launcher at White Sands Proving Ground was used in most Zeus development firings. Operational launcher will be vertical cell type, for underground firing.

escape unconfined after striking a reinforced concrete deflector. Subsequently, a "cell" type launcher was designed and built which provided for adjusting the degree of exhaust gas confinement.

This is a prototype which Burns & Roe Inc., A&E for facility design, says will lead to the ultimate development of an underground launcher. At White Sands Missile Range there is an underground launch control building which is designed to protect personnel and equipment from an accidental explosion of the missile. The safety factor accounts for the 125 acres needed for the batteries. Moreover, the Corps believes it will have to either get an easement for another 115 acres around each battery or build revetments to protect nearby populated areas.

Thought is being given to hardening the batteries. Missiles would be serviced via tunnels leading from the control buildings which house utilities, instrumentation, data transmission and equipment for remotely controlled warm-up and firing of the missiles.

It is estimated that about 500 tons of air conditioning will be needed for an acquisition site to control the environment of high-powered electronic gear. Design of the defense centers, as well as the batteries, called for solution of several unique problems—including special shielding of electronic equipment and personnel from spurious high-intensity RF energy. The inflatable radomes require a highly redundant pressurization system.

• **Fast reliability** — Basic power sources also are critical. Specs call for a reliability factor of only two 10-sec. interruptions per year. The Corps is planning to insure continuous power with a site-generated steam turbine equipped with a steam accumulator. This will maintain the system until a fast-fired spare turbine can be turned on.

Studies have been made of the practicality of using nuclear power. But only for remote areas outside the continental U.S.

R&D for base construction is being supervised at Redstone Arsenal by Col. Cecil Fuller, deputy chief of the Mobile District Corps of Engineers. Should there be a production go-ahead, base construction would be contracted through the various Corps districts covering the country—in much the same way ICBM and antiaircraft missile base contruction is handled.

Even in the event a full-scale deployment of scores of *Zeus* units is ordered, the Corps does not see any great burden being thrown upon it or the nation's construction industry. As one official puts it:

"If we get construction money for *Zeus*, we will get less for something else. Our worry is not getting it." ⠿

NIKE-ZEUS

Management Is All Ready to Roll

Army-industry team has been geared up for a year to go into mass production; elaborate planning involving hundreds of organizations calls for outlay of $5 million or more per day, if order comes for production program; leaders believe that basic theory of Zeus was well proven in Ajax and Hercules efforts

by Frank G. McGuire

THE ARMY-INDUSTRY TEAM guiding the development of *Nike-Zeus* is already highly organized to enter the A-ICBM into a mass production cycle.

It has been ready to go for a year.

During this period an enormous amount of study has been put into refining the means of bringing forth an operational *Zeus*—in all its complexity—in the shortest possible time. So that now, Brig. Gen. John G. Zierdt, chief of the Army Rocket and Guided Missile Agency, says production procedures and channels are "completely established."

Tooling up is expected to take about one year. But, for all its size, no requirement is seen for additional factory space. Neither will there be a production "line" as such for the system—only for components.

S. C. Donnelly, Western Electric *Zeus* project manager for production, has been organizing a production program since 1959 under a $19.9-million planning contract.

Donnelly has a team of about 1000 engineers at Western Electric's Burlington, N.C., works. They have been staying abreast of developmental changes during the R&D cycle to identify areas that will need attention during production. Their detailed plans cover production value analysis, reliability, quality assurance and design work on tools and facilities.

Moreover, they started to develop production equipment last year under a new $22-million contract. This included the design of pilot lines for the mass production of such items as high-reliability transistors, and other electronic parts—items which will be in demand even if *Zeus* is not funded for production.

• **$5 million daily**—Because of this advance work, Western Electric feels it is "in a good position to go into production now." As one company official put it:

"We've got a head start on the tougher nuts of bringing costs down."

Some idea of the magnitude of Donnelly's problems of moving into mass production can be gained by comparing the change in spending that would result.

Under the R&D program, the countrywide *Zeus* effort is spending an average rate of about $1 million a day. Under a production program, of any size, spending would increase to more than $5 million a day. Moreover, it is not only the amount of spending that is tremendous, but the size and complexity of the *Zeus* subsystems themselves.

The huge radars can not be assembled, tested and shipped; they must be assembled and tested at their deployment sites. The work of thousands of contractors, 14 government laboratories, and dozens of agencies cutting across DOD and the AEC must be coordinated into a production line not unlike that which has produced *Atlas* and *Polaris*.

In addition there are the multiple headaches of coordinating site construction schedules, tieing in the system with the North American Defense Command and solving the strategic questions involved in base deployment.

However, Western Electric officials regard *Zeus* in a broad sense as a natural successor to the *Nike-Ajax* and *Nike-Hercules* systems which they successfully produced.

• **Ajax was proof**—"The design concept is not based on any new theories that have never been tried before," one official said. "We are simply dealing with a longer range, and a smaller target moving at higher speed. The basic theory of *Zeus* was proven in *Ajax*."

Western Electric produced both *Ajax* and *Hercules* on a concurrent basis with their R&D programs.

With Hercules, the Army awarded Western Electric a prototype contract more than a year before the R&D models were completed. With *Ajax*, the first production model came off the pro-

ZIERDT

DONNELLY

CRANE

MANAGEMENT TEAM is headed by Brig. Gen. John G. Zierdt, ARGMA commander. S. C. Donnelly is Zeus project manager for Western Electric. Lt. Col. Glenn Crane, "Mr. Zeus," is ARGMA project director. Primary tool in management procedure is meeting of principal contractors every 4-6 weeks to iron out problems and knock heads together. Since program is countrywide, meetings are held in various regions. January get-together in Los Angeles included visit to Zeus facility at Pt. Mugu and to Douglas plant.

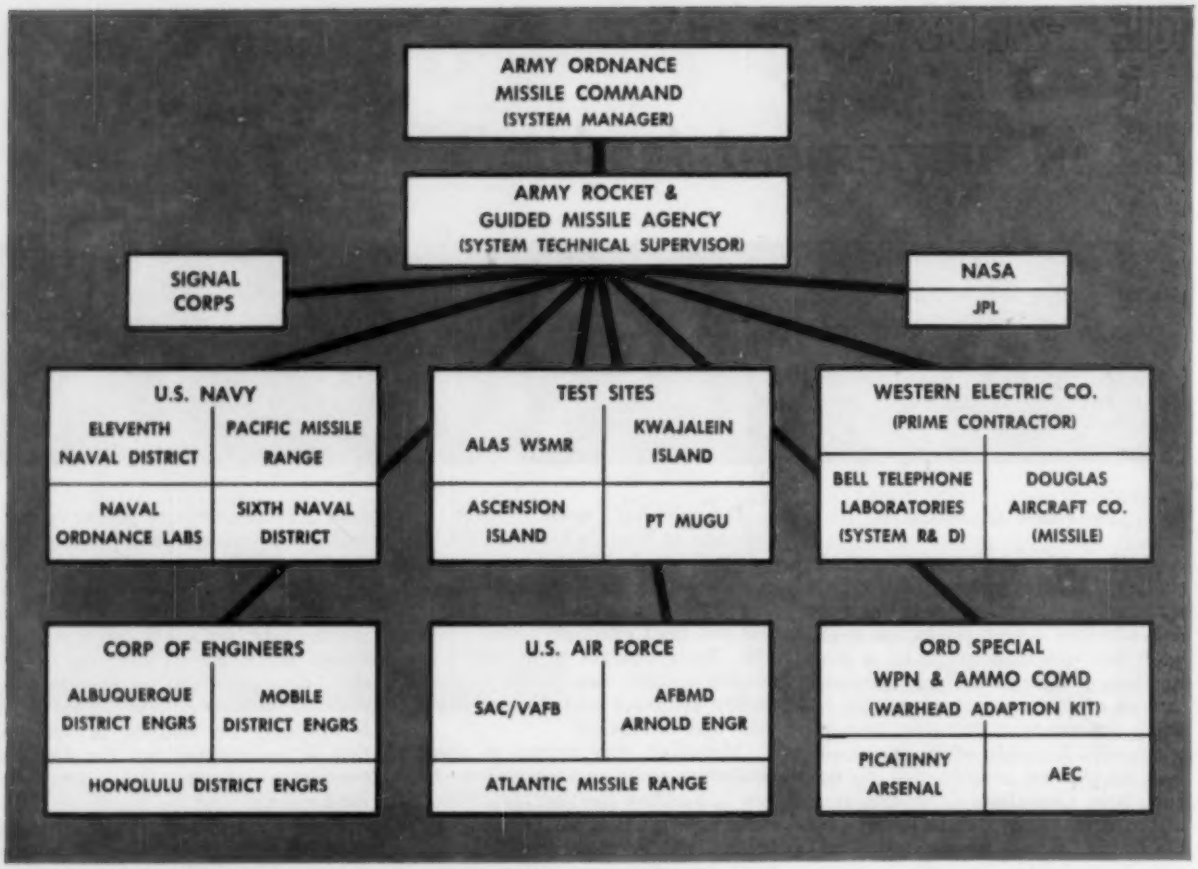


TABLE SHOWS AGENCIES PARTICIPATING in the Nike-Zeus program.

duction line only six months after the first prototype.

Western Electric and the Army believe in moving as quickly as R&D indicates production is feasible. Says Zierdt:

"There is a point at which the R&D phases of a weapon system reach a point of leveling off in their improvement of a system, and then it becomes mandatory to go into production or lose vital time."

Feasibility studies on *Zeus* began early in 1955. They were completed in 1956. The initial R&D contract was awarded late the same year and work actually began in early 1957. Both the Army and its industry team have been ready to begin production since late 1959.

No production team has been named in fact, but the general presumption has been that the present team headed by Western Electric (see page 54) would be selected.

Given a go-ahead, Western Electric would center its production control at Burlington.

The government-owned Burlington shops are the second largest of Western's North Carolina plants. Its 700,000 square feet of manufacturing space cover much of the former Tarheel Ordnance Plant.

Western moved into Burlington in 1946. Since then it has used the shops there for the assembly of *Ajax* and *Hercules* as well as ship-based gun directors and antennas. Presently, it is producing components for *Terrier* and *Titan* as well as advanced kits for converting *Hercules* to improved models.

The company-owned Winston-Salem works is the main Western Electric plant in North Carolina. It covers 1.5-million sq. ft. It has 7200 employes producing electronic components, while Western's 280,000 square foot plant at Greensboro has 1600 employes.

Conceivably, failure to obtain a production contract in the next few months might cause some layoffs among the Burlington plant's 4100 employes. It also would affect its 4000 suppliers. The end of 1960 saw the completion of the *Hercules* production run with the exception of the conversion kits.

• **Production planning**—In effect, during the past year, Western Electric has been putting together a series of master plans to roll *Zeus* batteries out at any rate desired by the Army.

The studies have been numerous and detailed. They have included:

–Lead time.

–Flow of equipment from second tier subs to tactical sites.

–Type of documentation necessary to support maintenance.

–GFE (for standardization, availability, etc.)

–Determination of standard production equipment necessary.

–Quality assurance program.

–Transportation. Special demands (expanded to include deployment and installation schedules.)

–Reliability in production.

–Possibility of "breakout" of items for competitive procurement from subs other than R&D companies. (A time phase schedule is being worked out for spare parts procurements and maintenance.)

–Production facility requirements.

–Missile motor cases production.

–Automated transistor production.

–Design of stable platform production.

–Development and inspection techniques for producing the missiles' ablative cover.

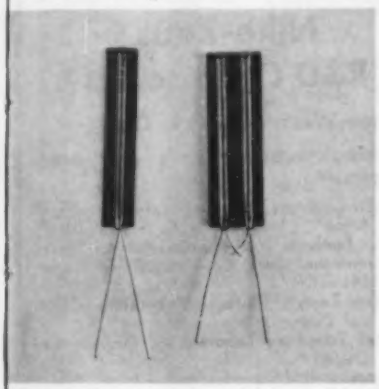
• **Logistic support**—The great problems of logistic support of a program of any magnitude has been given active

(Continued on page 54)

Microdot Acquires Micro-Test

Los Angeles — Microdot Inc. has entered the field of strain measurement devices through the acquisition of Micro-Test, Inc. of Santa Monica, California. Through this move, Microdot will manufacture and market the only weldable strain gage in the U.S. — a device that is capable of continuous operation at 800°F and dynamic test to 1500°F.

The weldable strain gage, used extensively in missile, space, and atomic projects, will be integrated with Microdot's existing pressure, force, and acceleration measurement capabilities.



Weldable strain gages, one-piece, etched wire filaments in swaged stainless steel tubes, are suitable for use from cryogenic to elevated temperatures. Photo shows typical gages in actual size.

The Micro-Test acquisition is in line with other current moves by Microdot to enhance and broaden the company's instrumentation capabilities. Other Micro-Test products to be offered by Microdot include: temperature sensors in 60 and 120 ohm resistances that are completely insensitive to strain, and hermetically sealed load cells with adjustable temperature sensitivity offered in ranges of from 5,000 to 50,000 pounds for both compression and tension-compression.

Microdot sees great potential for the application of these new devices wherever physical phenomena can be measured and controlled. The weldable strain gage is already being used in atomic reactors, the exterior of submarines, inside chemical vats, on pilings sunk into the St. Lawrence Seaway, and a wide variety of airborne defense projects.

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South Pasadena, California

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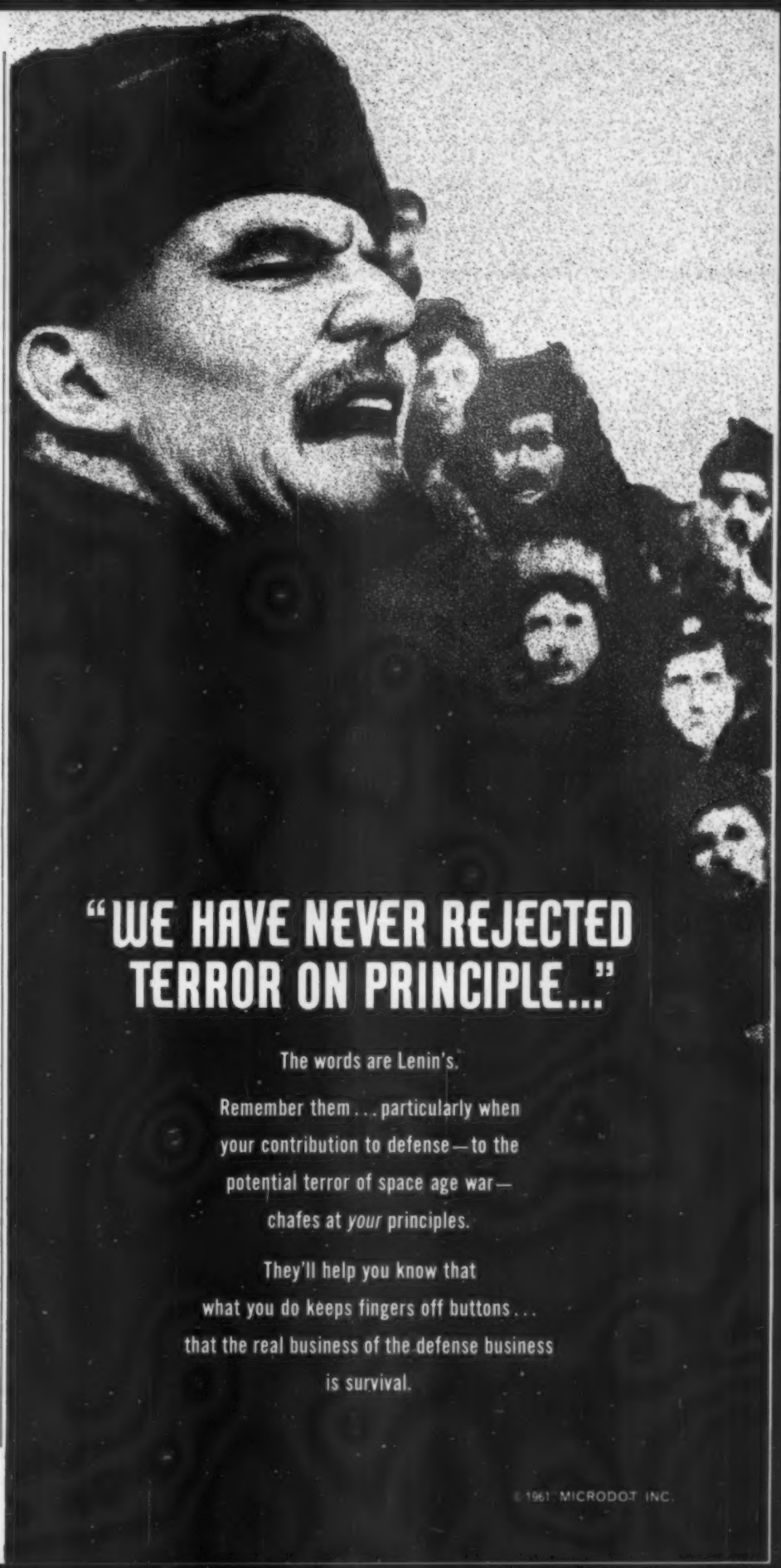
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Remember them . . . particularly when your contribution to defense — to the potential terror of space age war — chafes at *your* principles.
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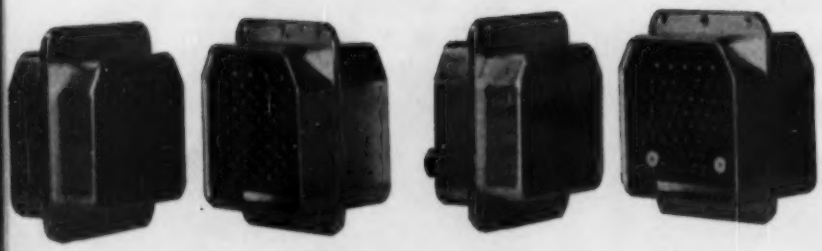
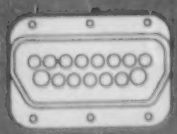
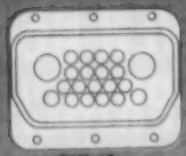
NEW FROM CEC...RACK AND PANEL CONNECTORS WITH MIL-SPEC CONTACTS



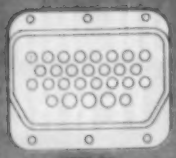
NOW FOR THE FIRST TIME you can have a rack and panel connector with contacts made in accordance with MIL-C-26636... an exclusive CEC feature. And they are available in six configurations... Die-cast aluminum shells in accordance with MIL-QQ-A-591A and insulator blocks of high-strength glass-filled diallyl phthalate per MIL-M-19833. Check these configurations with your requirements:



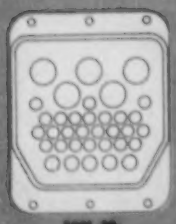
SCDL-15:
13 size 20 contacts,
2 size 16 contacts.



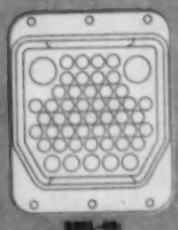
SCDL-19:
17 size 20 contacts,
2 size 16 contacts,
2 standard RG59/U coaxial contacts.



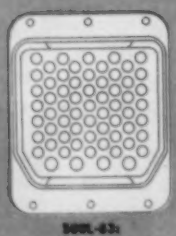
SCDL-25:
25 size 20 contacts,
3 size 16 contacts.



SCDL-30:
22 size 20 contacts,
5 size 16 contacts,
3 standard RG59/U coaxial contacts.



SCDL-43:
43 size 20 contacts,
5 size 16 contacts,
2 standard RG59/U coaxial contacts.



SCDL-63:
59 size 20 contacts,
4 size 16 contacts.

For more information, write for Bulletin CEC 4006-X7.

Electro Mechanical Instrument Division CEC

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(Continued from p. 52)

consideration during the R&D phase.

Handling of the more than 100,000 spare parts will be done with high-speed communications to supply depots. While special Composite Support Units comprised of Ordnance, Engineers and Signal Corps personnel will handle maintenance.

Training of cadres for operational units is under way.

The Army and industry say they are ready—all they need is the word from the White House. ¤

Nike-Zeus R&D Contractors

Prime—Western Electric Co.

Principal subcontractors and area of effort*

- **Allis-Chalmers Mfg. Co.**—Target track antenna
- **Air Products, Inc.**—Refrigerator for Maser
- **Armstrong Cork Co.**—Acquisition Radar Dielectric
- **Avco-Everett Research Laboratory**—Optical Discrimination
- **Bell Telephone Laboratories, Inc.**—System Design
- **Bomarc Laboratories, Inc.**—High Power Duplexer
- **Burns and Roe, Inc.**—Facility Design
- **Continental Can Co., Inc.**—Tracking Antenna Mounts
- **Continental Electronics Mfg. Co.**—Acquisition Radar Transmitter
- **Douglas Aircraft Co., Inc.**—Missile, Booster, Missile-Handling and ***Test Equipment***
- **Doehler-Jarvis**—Wave Guides
- **Dow Chemical Co.**—Acquisition Radar Dielectric
- **Eagle-Picher Co.**—Battery packs
- **F.X.R., Inc.**—Rotary Joints
- **Goodyear Aircraft Corp.**—Acquisition Radar Antenna
- **I.T.E. Circuit Breaker Co.**—Rotary Joints
- **Kaydon Engr. Corp.**—Bearing Assemblies
- **Lear, Inc.**—Stable Platform
- **Arthur D. Little**—Refrigeration System
- **Messinger Bearing Inc.**—Radial Bearing
- **Minneapolis-Honeywell Regulator Co.**—Accelerometers
- **Narmco Mfg. Co.**—Target Track Antenna
- **Remington Rand Univac**—Computers
- **Sperry Gyroscope**—Target Track Radar Transmitter
- **Steel Products Eng. Co.**—Missile Track Radar Antenna
- **Stromberg-Carlson Co.**—Test Equipment
- **Texas Instruments, Inc.**—Tactical Displays
- **Thiokol Chemical Corp.**—Booster
- **Transfilm-Caravel Inc.**—Motion Pictures
- **Vickers Inc. Div. of Sperry Rand Corp.**—Target Track Antenna, missile APU's
- **Waterman Products Co.**—Oscilloscopes
- **Western Gear Corp.**—Gear Reduction Unit, Drive Gear
- **Westinghouse Electric**—Hydrodynamic Bearing
- **Wheeler Laboratories Inc.**—RF Plumbing

**As listed by Western Electric Co.*

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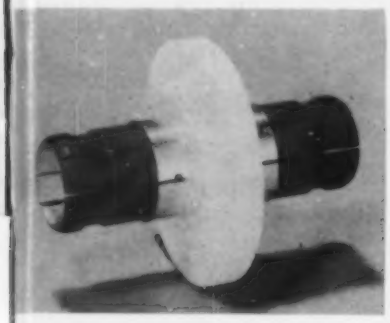

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Prodelin, Inc. has available a lubricated coaxial transmission line anchor insulator connector that assures the elimination of galling on bullet type inner conductor contact surfaces. This exclusive Prodelin product was especially designed to eliminate high power transmission line failures caused by the balling of bullet contact surfaces resulting from differential expansion between inner and outer conductors.

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Gallium Arsenide Crystals

The Electronic Chemicals Division of Merck & Co., Inc. is manufacturing single crystal gallium arsenide in production quantities. The material is available in both doped and undoped form with carrier concentrations ranging from $1x10^{16}$ carriers per cubic centimeter to degenerate levels. Crystals can be delivered to a doping tolerance of + or – 50%. Dopants employed are zinc, tellurium and tin.

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Barometric Timer

A type of barometric timer applicable to pilot escape systems, high speed air cargo drop systems and certain missile arming or recovery systems is available from Patterson Moos Research Division of Leesona Corp.

The device, about 4 in. long, less than 1½ in. in diameter and weighing 0.5 lb. is a mechanical clockwork mechanism which provides a fixed time-delay between the time and arming pin is pulled and a pressure cartridge is fired. An internal aneroid block senses altitude and prevents operation outside certain pre-set altitude. An aneroid leak indicator warns of malfunction.

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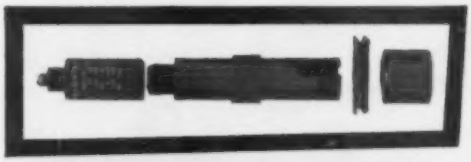
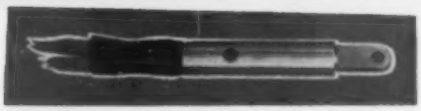
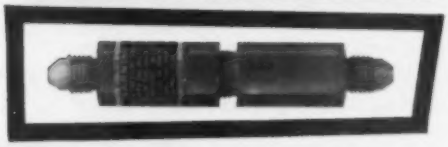


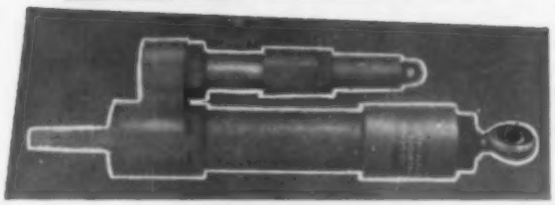
Cartridge Actuated Cable Cutter, Model No. 133
for cutting up to ¼" dia. steel cable, wire or tubing. Reusable, with replacement of integrated knife/cartridge.



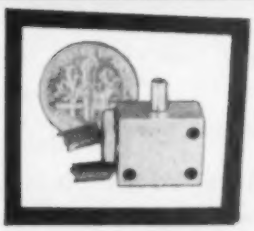
Linear Actuator, Model No. 128
for direct or linkage actuation—with two complete and totally independent ignition systems.



Ballistic Delay Initiator, Model No. 367
for delayed or instantaneous gas initiation—can be modified for various delay and/or pressure outputs.



Cartridge Actuated Thruster, Model No. 298
Locked before firing and at end of stroke. Can be modified for either gas or electrical actuation.



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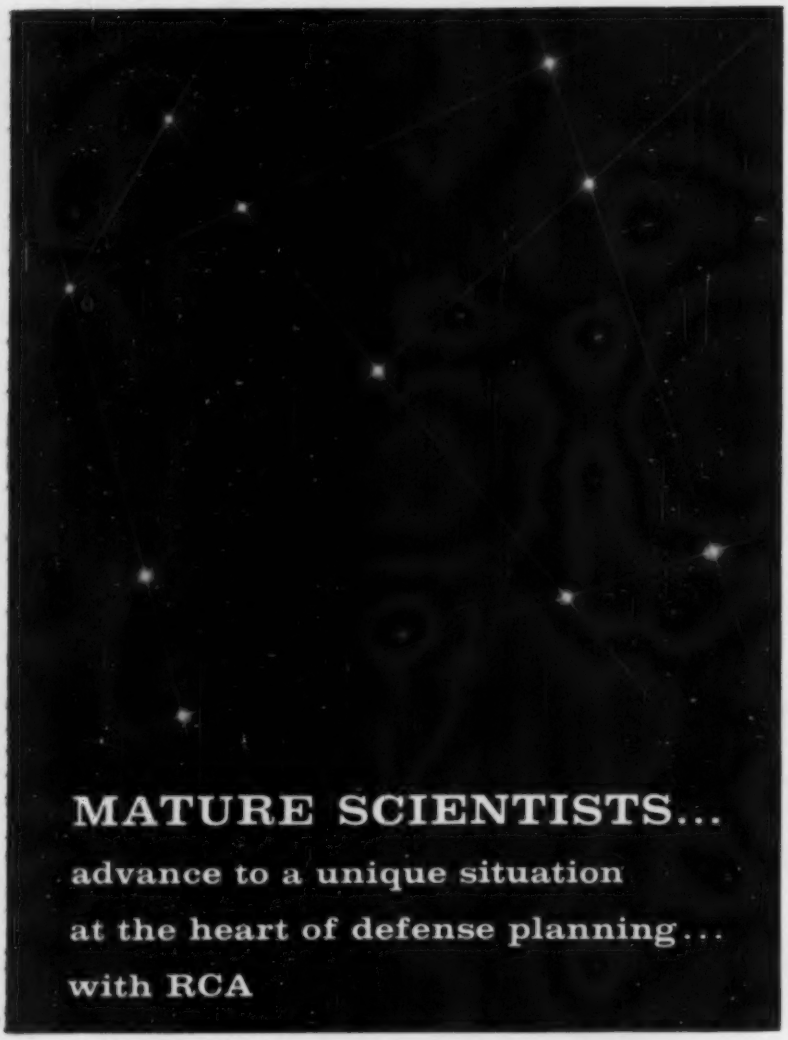

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Filmohm Corp. is marketing a metal film resistance card, a highly stable microwave attenuator material. The base is a fine weave glass cloth impregnated with high temperature thermosetting resin which meets MIL-P-18177. Resistance material is a thin film of pure metals, approximately 50 millionths of an inch thick, uniformly deposited on one surface of the plastic. A protective coating is provided.

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Rotary Commutators

Rotary Commutators for analog-digital conversion, telemetry, sampling, scanning, programing, and pulsing are available from Airflyte Electronics. Gold or rhodium plated contacts are firmly embedded in epoxy resin and diamond turned to 4-6 micro-inch stepless finish. Commutating surfaces are engaged by special broom type multiple strand brushes to produce minimum noise and life expectancies in excess of 2×10^7 cycles at up to 2000 RPM.

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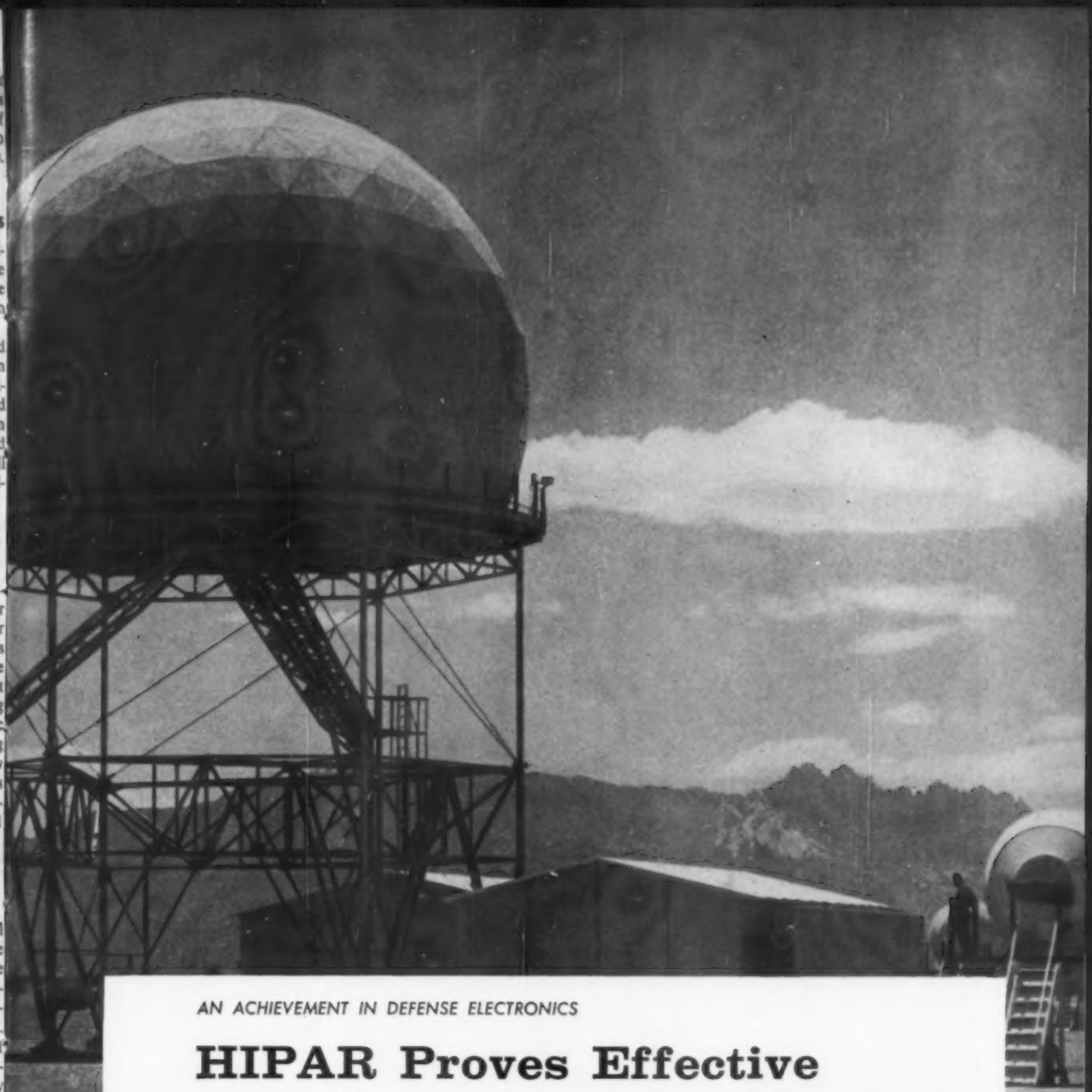

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HIPAR Proves Effective In Hercules Anti-Missile Test

This new General Electric *High Power Acquisition Radar* (HIPAR) more than triples the detection capability of the U. S. Army's Nike-Hercules System. Produced for Western Electric, Nike-Hercules System Prime Contractor, this General Electric radar provides high resolution target data at long range and high altitudes on bomber and fighter aircraft, air-launched missiles and tactical ballistic missiles. The effectiveness of this Improved System was demonstrated at the White Sands Missile Range on June 3, 1960, with the successful intercept and destruction of a Corporal Missile, and in August and September, 1960, when target Nike-Hercules Missiles were destroyed by their defending counterparts at altitudes to almost 100,000 feet and closing speeds near Mach 7. 176-06

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industry

GENERAL ELECTRIC has estab lished a new operation at Palo Alto Calif., to centralize its nuclear power design and development activities for specialized applications such as manned and unmanned space vehicles and satellites.

INTERNATIONAL TELEPHONE & TELEGRAPH has joined its I T Laboratories to the ITT Federal Di vision to form a single operating uni which will be known as ITT Federal Laboratories.

THOMPSON RAMO WOOLDRIDGE is moving nearly 200 TRW personnel from offices in the Los Angeles area to Canoga Park headquarters. Among those involved in the move are 120 members of the TRW Computers Company, formerly headquartered in Beverly Hills.

DOUGLAS AIRCRAFT CO. has started the first phase of a $2-million modification program at its Sacramento field station in preparation for system and static testing of the *Saturn S-IV* and other space vehicles. Major items in the program include the installation of a liquid hydrogen storage and transfer system and the altering and enlargement of two test stands for cold-flow testing and static firings of the *S-IV*.

THE MARQUARDT CORP. Pomona Division has moved into a new 27,500-sq.-ft. engineering building in the same city.

TENNEY ENGINEERING has formed a division to design, develop and produce ground and flight support devices.

W. L. GORE & ASSOCIATES, manufacturer of Teflon-insulated wire and cable, has completed a move into a new plant near Newark, Del., adjacent to its old plant.

IBM FEDERAL SYSTEMS DIV. will complete its new Communications Center at Rockville, Md., near Washington, D.C. on Feb. 1. Research at the 38,000-sq.-ft. center will emphasize improvements in systems design and reliability in both radio spectrum and direct wire communications.

ILIKON CORP., founded by a group of MIT scientists for materials research, has opened offices and a research laboratory in the Natick Industrial Centre, Natick, Mass.

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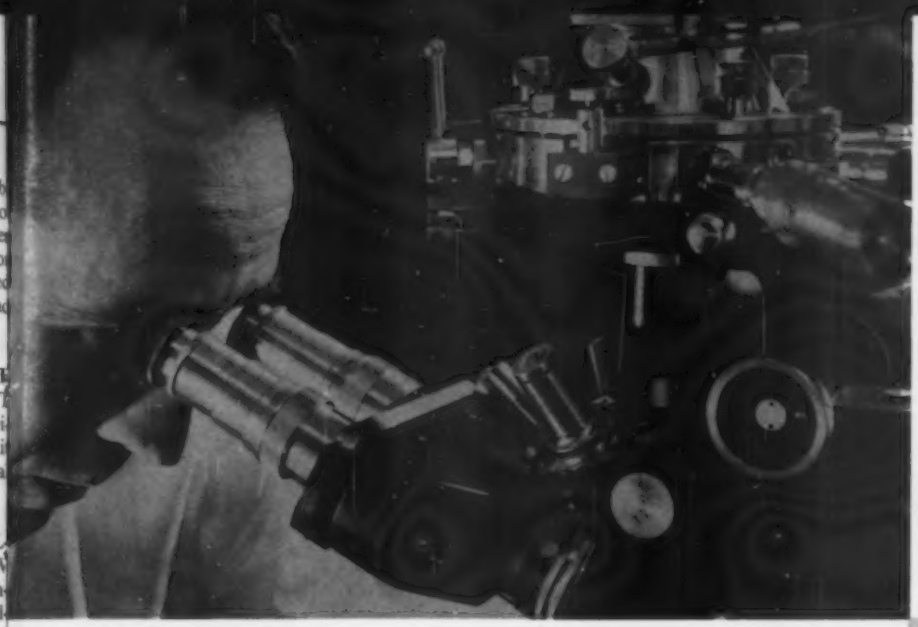
Circle No. 17 on Subscriber Service Card.



Extremely high temperature material problems encountered on reentry into earth's atmosphere are studied with the aid of a plasma jet capable of 30,000°F.

Basic effects of elevated temperatures on various materials are viewed and photographed with the hot stage microscope.

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The experienced Vickers Application Engineer in your area will welcome the opportunity to fill you in on additional details. In the meantime, write or call for Bulletin A-6002.

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Analog computer (shown) and solid state Univac digital computer give Vickers the important edge in solving complex engineering problems.

names in the news

Homer R. Denius: President of Radiation Inc., elected chairman of the board. He will retain the presidency. Mr. Denius, one of the founders of the firm in 1950, was formerly vice president and chief engineer of Melpar, Inc.

Robert E. McDowall: Vice president of Cohu Electronics, Inc., elected to the board of directors of Exact Engineering & Manufacturing, Inc.

W. E. Cleator and **G. Jewett Crites:** Vice president and director of future planning, respectively, elected to the board of directors of Tool Research and Engineering Corp.

Richard S. Cesaro: Appointed vice president, corporate planning, research and development at Autometric Corp. Was formerly technical director and scientific consultant to ARPA—Advanced Research Projects Agency, Institute for Defense Analyses-Office of the Secretary of Defense.

Walter H. Powell: Vice President of Industrial Relations for International Resistance Co., named vice president of Operations.

William H. Rous: Appointed vice president, International Operations, Amphenol-Borg Electronics Corp. He will continue to serve as vice president, marketing.

Paris H. Stafford: Chief Engineer for Permanent Filter Corp., promoted to vice president in charge of engineering. Prior to joining the firm in 1952, he served as supervisor of guidance and control equipment in the Autonetics Div. of North American Aviation.

Elwood Roger Zeek: Joins The Diehl Manufacturing Co. as vice president in charge of research and engineering. Was formerly associated with the Walter Kidde & Co., Inc.

Henry Feldmann: A founder and board chairman of FXR, Inc., resumes the presidency of the company, succeeding **Tore N. Anderson,** who has resigned.

Ralph F. Gow: Elected president of Norton Co. **Milton P. Higgins,** president since 1946, moved up to chairman of the board, succeeding **George N. Jeppson,** who now has the title of honorary chairman.

Warren W. White: Appointed to the newly created post of assistant director of engineering for Robertshaw-Fulton's Aeronautical and Instrument Division. Was formerly supervisor of instruments products engineering.

General Nathan F. Twining (USAF, Ret.), former chairman of the Joint Chiefs of Staff, last week received the National Security Industrial Assn. James Forrestal Memorial Award. The award is presented annually to the man who, in the opinion of NSIA members, has "contributed most to cooperation between industry and the Defense Department."

Harry L. Hildebrand: Former manager of process and design engineering for Taylor Fibre's plants at Norristown and LaVerne, Calif., joins Dytronics, Inc. as general manager.

Dr. Harold V. Hance: Joins the Systems Research Center of Lockheed Electronics Co. as both associate director of the center and a senior scientist. Was formerly senior scientist in the Research and Development Laboratories at Hughes Aircraft.

David Fales III: Named chief engineer for Gabriel Electronics, Division of The Gabriel Co. Was formerly manager of electronic product sales and staff engineer for The Martin Co., Baltimore.

Dr. Curtis E. Miller: Appointed director of the Medical Sciences Dept. of Dynamic Science Corp., a subsidiary of Marshall Industries.

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Missile/Space Week

(Continued from page 14)

10-year development of titanium technology. Current problems include improving the physical characteristics, reducing the cost and removing the toxicity hazard.

New Mercury Flight Plan

The *Mercury Redstone-2* Chimpanzee-bearing capsule test, scheduled for this week, will follow a lower, flatter trajectory than last month's successful *MR-1* flight.

Peak altitude will be 115 statute miles instead of 130, while the capsule is aimed at a spot in the Atlantic 290 miles downrange from Cape Canaveral, instead of 235 miles. The trajectory was lowered for range safety considerations and to reduce re-entry g loads from 12½ to about 11.

MR-2 will be the first flight in the *Mercury* series to fully test the Abort Sensing Instrumentation System (ASIS), which orders firing of the escape rockets in case it detects anything going wrong. In previous flights the system has operated on open loop—that is, the signals were given but the escape rockets were set to fire only on command from the ground.

The flight will also mark the first flight test of the life support system. It will also have a psychomotor test to determine whether the chimpanzee can perform functions it can carry out on the ground and whether launch, weightlessness and re-entry have any physical or psychological effects on the animal.

A movie camera will photograph the animal during flight for observation of the chimp's state of awareness.

The psychomotor test is a game involving three colored lights, two levers and a faint electric shock applied to the animal's foot if he does not obey the rules. The six chimpanzees have become quite proficient in the game during training at Holloman AFB, N. M.

The chimpanzee and a backup animal, which will also be wired with telemetry equipment and kept on the ground, will be chosen from a group of six at the Cape 24 hours before the launch. The launched animal will be in a special couch with oxygen lines to the regular life support system.

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First Polaris Sub Returns

THE OFFICERS of the nuclear-powered submarine George Washington first of the *Polaris* fleet, are giving high marks to her maze of equipment for its performance during her first deployment on station.

Cmdr. James B. Osborn, skipper of the George Washington, said after returning from the cruise Jan. 21:

"My crew and my ship performed above my expectations. The missile system was better than even we hoped it would be. And be don't pass out pretty good marks for nothing."

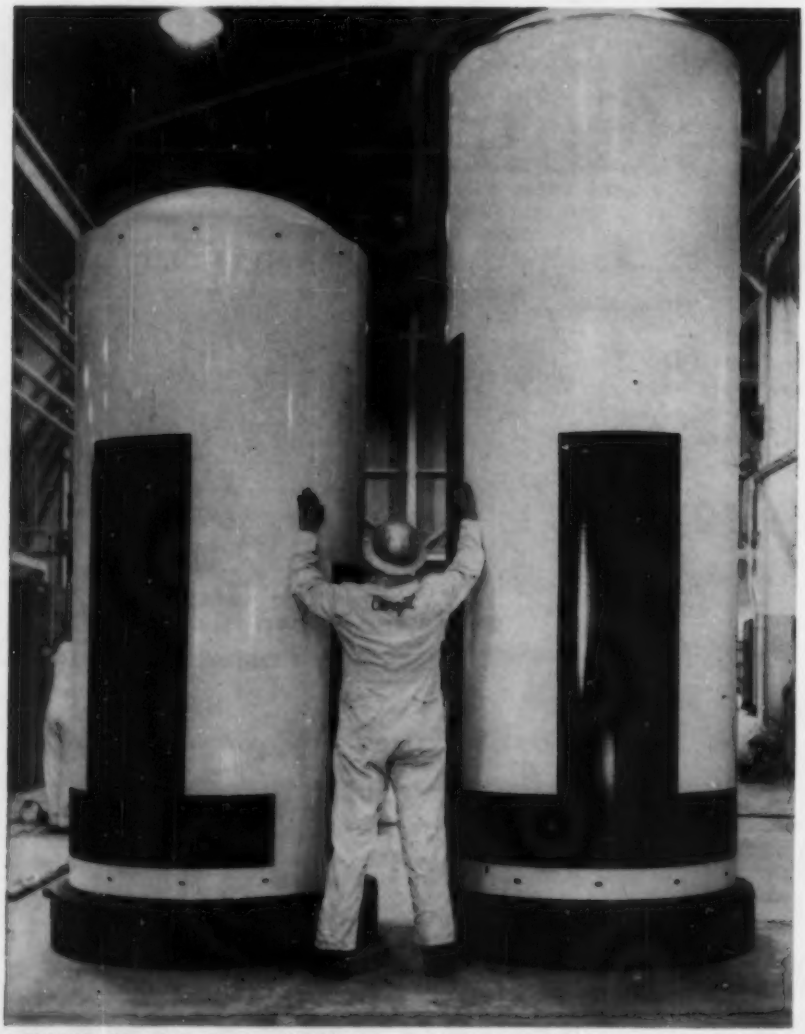
The George Washington tied up beside her tender, the Proteus, nearly 67 days after deploying from the Naval Weapons Annex near Charleston, S.C., on Nov. 15.

She had operated submerged and "buttoned up" for approximately 66 days and 12 hours—a record. The old record, held by the nuclear-powered sub Seawolf, was 60 days, 10 hours, 23 min.

The George Washington will be completely serviced by the Proteus before deploying again with a fresh crew. Then the Proteus will sail for her permanent advanced base at Holy Loch in the Clyde Estuary, Scotland.

The Navy directed the Proteus to take on her first servicing job at New London to make certain that her facilities are adequate and to provide back-up equipment if necessary.

"You might say we are cutting our teeth on the Gorge Washington," one officer said. ⌗



COMING UP FOR George Washington and her sister ships is the 30-inch-longer Polaris II (A2) model with its 1500-mile-range. An Aerojet technician stands before a Polaris I (A1) and Polaris II first-stage motor case to show their comparative sizes.

In FY 1960

General Dynamics and Lockheed Led in Awards

GENERAL DYNAMICS CORP. tops the list of 100 companies and 118 subsidiary firms that received the largest dollar volume of military prime contracts during Fiscal Year 1960.

General Dynamics received $1.2 billion of the $15.4 billion of prime contracts totalling $10,000 or more awarded the 100 companies. Lockheed and it subsidiaries ran second with $1.01 billion.

Positions were reversed for the two firms in the list of the top 400 prime commercial contractors that received the largest dollar volume of military prime contracts for experimental, developmental, test and research work.

Lockheed received $666.3 million. General Dynamics received $528 million.

The total new value of all EDTR awards of $10,000 or more increased during FY '60 from $5.2 billion to $5.5 billion.

The first fifteen companies in prime contracts, in addition to General Dynamics and Lockheed, included:

Boeing Airplane Co., third, $1 billion; General Electric Co., fourth, $963.1 million; North American Aviation, Inc., fifth, $907.7 million; The Martin Co., sixth, $596.7 million; United Aircraft Corp., seventh, $517.4 million; American Telephone & Telegraph Co., eighth, $466.8 million; Radio Corp. of America, ninth, $405.8 million; Douglas Aircraft Co., 10th, $404.9 million; Hughes Aircraft Co., 11th, $349.1 million; Raytheon Co., 12th, $323.4 million; Sperry Rand Corp., 13th, $296 million; International Business Machines Corp., 14th, $290 million, and Republic Aviation Corp., 15th., $265.1 million.

The top fifteen firms in EDTR prime contracts, in addition to Lockheed and General Dynamics, included:

North American Aviation, Inc., third, $473.8 million; General Electric Co., fourth, $396.7 million; Western Electric Co., Inc., fifth, $270.3 million; The Martin Co., sixth, $245.8 million; Boeing Airplane Co., seventh, $205.7 million; Aerojet-General Corp., eighth, $182.5 million; Sperry Rand Corp., ninth, $120.1 million; Westinghouse Electric Corp., 10th, $118.4 million; Douglas Aircraft Co., 11th, $100.3 million; Thiokol Chemical Corp., 12th, $99.4 million; Radio Corp. of America, 13th, $92 million; General Motors Corp., 14th, $81.6 million, and Avco Corp., 15th, $80.8 million. ⌗

Discoverer Communications 'Pinpoint'

Philco says high accuracy of communications and control system is responsible for recovery successes in program

PALO ALTO, CALIF.—Details of the communications and control system for recovery of Air Force *Discoverer* satellite vehicles indicate growing AF confidence in its ability to recover instrument capsules on an almost-routine basis.

Latest information was revealed by Philco Corp.'s Western Development Division, associate prime contractor on the communication and control aspects of *Discoverer*, which said pinpoint accuracy of the network has been responsible for successful recoveries so far.

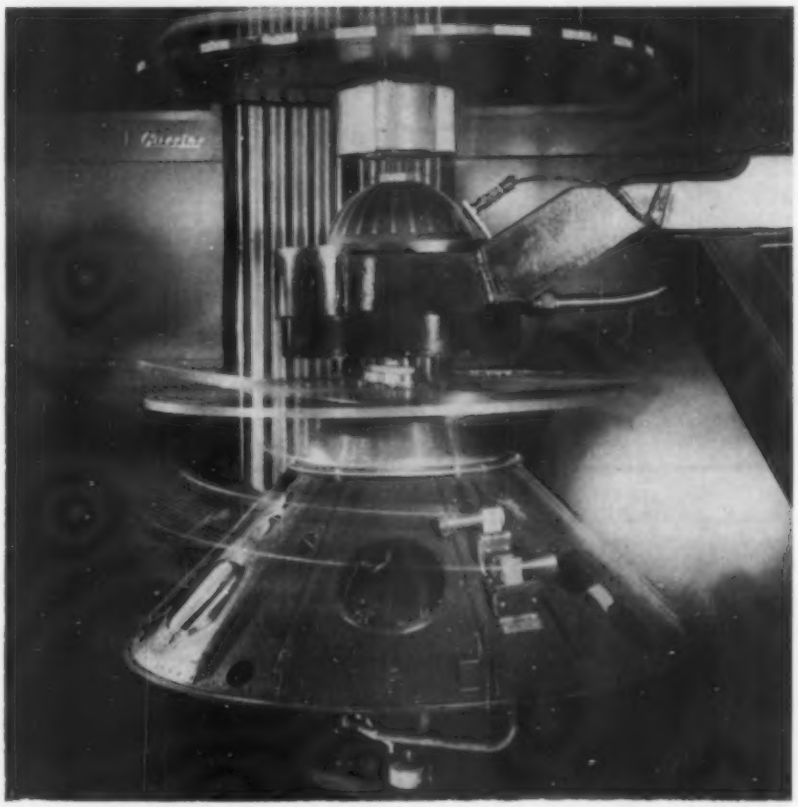
(Almost simultaneously, Lockheed Missiles and Space Division pinpointed axial instability as the cause of earlier recovery failures.)

The entire communication and control portion of the *Discoverer* vehicle is designated Subsystem H, and has four basic functions: to provide tracking data on the satellite and its instrument capsule; to command the vehicle to perform such functions as second-stage ignition, capsule ejection, and other command functions; to collect telemetry data; and to insure that all events are carried out on a common time basis.

• **Equipment** — Four interlocked electronic subsystems make up the complex: a long-range tracking radar to provide azimuth, range and elevation data, including an analog computer to assist in acquisition of the satellite; a command subsystem operating over the radar link; a Doppler telemetric reception subsystem; and a data processing and transmission subsystem.

Satellite-borne equipment includes four sources of rf energy: a vhf cw oscillator for providing a continuous signal for initial acquisition; an S-band pulse-beacon transponder; an S-band beacon in the recovery capsule, energized after capsule ejection; and an FM/FM telemetry transmitter.

Ground equipment consists of a Doppler-receiving unit which picks up the cw oscillator signal for target acquisition via a tri-helix antenna; the VERLORT (very-long-range tracking) radar which triggers the pulse beacon transponder at ranges up to 2500 miles; and the telemetry receiver subsystem.



AXIAL DEVIATIONS were plotted photographically with this air-bearing test bed, according to Lockheed, thus solving a major re-entry problem in the Discoverer recovery program. Test vehicle is rigidly suspended from bottom of bearing.

Antennas of all three subsystems are slaved together during operation, usually after the tri-helix antenna has made initial acquisition as the satellite rises over the horizon from the north. The primary ground station is at Kodiak, Alaska.

Human control over the complete operation is administered from the master control console, the focal point of all display and control data. All information received at the ground station is fed into a processing and transmission system, composed of high-speed teletype circuits and other equipment, to keep the AF Satellite Test Center at Sunnyvale, Calif., informed of the satellite's position and status.

About fifty separate telemetering elements make up the system, which Philco says is virtually free of redundant design features but suffers no loss in reliabilty.

• **Discoverer mission** — As spelled out by Philco, the nominal sequence in a *Discoverer* mission is as follows:

Optical tracking utilized at liftoff is switched to radar surveillance immediately upon confirmed radar acquisition above the surrounding ground clutter and transmitter-pulse clutter pattern. The VERLORT radar at Vandenberg AFB is slaved to the optical tracking unit to assure radar acquisition. The destruct radar at VAFB is under separate control of the ground safety officer.

The target is tracked through its

launch phase until the time comes to pass it to the Point Mugu radar center. This center includes a computer for determining time-to-fire of the second stage.

The system computes the situation of the satellite, using the station's angle and ranging information to command second-stage ignition and control burning time. A tracking ship 900 miles downrange transmits performance data to the Satellite Test Center (STC) by way of a single-sideband radio link.

To conserve power, all instrumentation except the cw acquisition transmitter is turned off on the first orbit.

Data computation is centralized at STC, where corrections in planned performance are made, based on actual vehicle performance. The revised data are put on the teletype circuit to all tracking stations, which store the information on an acquisition programer enabling tracking antennas to look at a selected point on the vehicle's orbit where it is expected to rise over the horizon.

In this aspect of the operation, redundancy is utilized to insure acquisition by using the orbital computer of each VERLORT unit as a backup method of predicting the point of expected acquisition.

When the time of expected acquisition nears, the tri-helix antenna array of the Doppler subsystem is trained on the target spot in space. The continuously operating cw oscillator provides the first signal for the ground station, and a refined acquisition data estimate is made. The other two antennas in the ground complex are slaved to the tri-helix antenna, and the VERLORT radar locks onto the vehicle, the electronics of which have since been turned on. ⌗

Tiros II Reduced to IR, Direct Observation

TIROS II WEATHER information now is limited to infrared observations and direct readout of cloud-cover photographs while the satellite is in view of ground stations.

A malfunction in the timing clock operation and the wide-angle camera system threatening total power drainage made necessary an indefinite suspension of programing wide-angle photographs on Jan. 18.

A different erratic behavior made it necessary to temporarily suspend programing of the narrow-angle camera system. However, scientists of the National Aeronautics and Space Administration expected programing would be resumed after a system analysis.

Tiros II, launched Nov. 23, took 9524 wide-angle photographs that could be usefully interpreted. ⌗

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AT&T Authorized to Use Two Gigacycle Channels by FCC

Firm may win inclusion in Relay project or it may get launch service for vehicle at cost from NASA

AMERICAN TELEPHONE & Telegraph Co. has authority to make use of two channels in the gigacycle spectrum for communication satellite experiments this year, but a launch vehicle may not be available until 1962.

The National Aeronautics and Space Administration, meanwhile, is asking for bids by March 6 on Project *Relay*, a program for developing and demonstrating an active repeater communications satellite.

It is possible that the AT&T plan, approved by the Federal Communications Commission, might be accepted as the industry program on Project *Relay*. It is equally possible that NASA might go ahead on a contract with one company and arrange to provide launch service at cost to AT&T for its satellite.

The launch vehicle involved is the *Delta*. Two additional *Deltas* are to be procured for the communications satellite program with part of a requested $24-million supplemental appropriation for the current fiscal year.

The lead time requirement on *Delta* vehicles means that a new one added onto the program cannot be available for mating with the spacecraft at Cape Canaveral before May 1, 1962. However, there are two backup vehicles in the nine to be launched in the present program over the next 18 months. Conceivably, one of these might be available.

• **Reassurance**—NASA spokesmen emphasized that the one-year limit on the license granted to AT&T is merely routine and is subject to routine renewal. Thus, they argued, the license sets no time limit making any haste necessary in negotiating arrangements.

The FCC authorized AT&T to use the 6325-6425 megacycle channel for transmitting to its experimental satellite with 3-kilowatt power and the satellite was authorized to transmit at 5 watts in the 4100-4200 megawatt channel. Both bands were taken from bands already assigned to common carriers. The experiments will include investigations of the feasibility of sharing channels between satellite-ground links and point-to-point earth communications.

The commission thus rejected the company's application to use the 6425-6925 mc band for the experiments. In a separate order, the FCC also rejected as premature the company's proposal that the 6425-6925 mc band be assigned to satellite relay use on a shared basis with other services. The order was announced on Jan. 19, the last day of the Eisenhower administration.

The FCC reported that the AT&T satellite would cost $250,000 and that launch costs were estimated at $3 million. The cost of the earth station at Holmdel, N.J., was estimated at $106,000. The commission authorized the company to use the channels for experiments involving as many as six satellites.

• **Price tag later**—NASA spokesmen said discussions with AT&T had not even reached the negotiation stage on the price the government will charge the company for launching its satellite. The discussions are continuing on technical details of the AT&T proposal.

It was understood that NASA does not intend to conclude the arrangements with AT&T until it receives an indication of the attitude of the Kennedy Administration and Congress toward former President Eisenhower's order authorizing the agency to make launch facilities available to private industry at cost.

NASA's Goddard Space Flight Center briefed industry on requirements for the Project *Relay* satellite Jan. 24 and 25. The specifications called for use of government-assigned frequencies of 400-500 mc for the satellite transmitter and 2200-2300 mc for the ground station. But the specifications allowed for substitution of other frequencies by the contractor if a good reason were given. This obviously enabled AT&T to substitute the frequencies assigned to it by the FCC.

The FCC authorized AT&T to communicate with experimental stations in the United Kingdom, France and the German Republic. AT&T commented:

"We are pleased with the Commission's decision because we can now firm up our plans for the next step toward a space communications system. We are most anxious to have an active satellite in orbit within a year and will push vigorously toward this. To do so, we have asked the government to supply launching facilities and we have offered to pay the costs."

Earlier this month, AT&T announced that the Bell System showed a profit of $1.244 billion in the 12 months ended last Nov. 30—an all-time record level of profits for one company in one year. The previous high of $1.189 billion was set by General Motors in 1955. ⌗

Relay Satellite Specifications

Weight	85 lbs. ± 10%
Shape	Cylinder leading to truncated cone capped by hemisphere
Total length	50.25 in.
Cylinder length	16.25 in.
Max. diameter	29.0 in.
Min. diameter	10.0 in.
Launch vehicle	Delta
Transmitter frequency	400-500 mc
Receiver frequency	2200-2300 mc
Power supply	solar cells, batteries
Apogee	2500-3000 naut. mi.
Perigee	600-1400 naut. mi.
Orbital inclination	30°-55°
Period	180 min.
Temperature required	40°-70°F
Operating life	One year
Radiation package weight	19 lbs.
Radiation package volume	90 cu. in.
Radiation package power need	6½ watts

Hughes to Build NASA's Surveyor Spacecraft

SURVEYOR, a 750-lb. package of television cameras, a drill 18 in. long and sophisticated scientific instruments, will make seven flights leading to soft landings on the moon in the period 1963-66.

The National Aeronautics and Space Administration is negotiating with Hughes Aircraft Co. for developing and producing the spacecraft, at a cost upwards of $50 million. T. Keith Glennan approved selection of Hughes over three other companies on Jan. 19.

The *Surveyor* spacecraft will weigh about 2500 lbs. when launched into a lunar trajectory by an *Atlas-Centaur* vehicle. Most of the weight will consist of solid propellant for a retro-rocket designed to slow the lunar landing speed to between 5 and 10 mph, a little slower than a manned parachute landing on earth. ⌗

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contracts

NASA

$3,008,000—Packard Bell Electronics Corp's Technical Products Div., Los Angeles, for development of an automatic checkout system for the *Saturn* booster.

$105,000—Chance Vought Astronautics, Dallas, for orbital launch operation studies investigating technical and economic feasibility of launching space vehicles from an earth orbit.

$92,000—Douglas Aircraft Co., Santa Monica, Calif., for orbital launch operation studies investigating technical and economic feasibility of launching space vehicles from an earth orbit.

NAVY

$700,000—Royal Industries, Inc., Los Angeles, for atomic reactor control rod actuators to be used on atomic submarines. Subcontract from **Westinghouse Electric Corp.**

$600,000—Summers Gyroscope Co., Santa Monica, for spring-wound gyros for use in the *Bullpup*.

ARPA

Atlantic Research Corp.'s Space Vehicles Group, Pasadena, Calif., for all engineering, fabrication and field services for six firings of the four-stage *Trailblazer II* rocket vehicle. Subcontract from **Massachusetts Institute of Technology, Lincoln Laboratory.** Amount not disclosed.

Ryan Aeronautical Co.'s Aerolab Development Co., Pasadena, has received contracts for seven *Trailblazer I* six-stage rocket vehicles to be used in re-entry vehicle research.

AIR FORCE

$3,590,177—Burroughs Corp., Detroit, for installation and logistic support of data processing equipment for the *Sage* program.

$176,000—Republic Aviation Corp., for development of extrusion processes for titanium metal.

$100,000—Boeing Airplane Co.'s Aero-Space Div., Seattle, for building rocket engine fuel tanks from spun glass threads.

$49,454—Electro-Optical Systems, Inc., Solid State Div., Pasadena, for research and investigation of tunnel emission amplifiers.

ARMY

$1,589,144—Universal Molded Fiberglass Corp., Bristol, Va., for 96,137 shipping and firing containers for the *M55* rocket.

$169,650—Telemeter Magnetics Inc., Los Angeles, for digital memory system.

$120,000—Sperry Rand Corp., Salt Lake City, for publications for the *Sergeant* missile system.

$119,490—Raytheon Co., Waltham, Mass., for replenishment repair parts for the *Hawk* system.

$110,000—New Mexico State University, University Park, for field testing and evaluation studies within the missile programs.

$86,352—Radioplane Div., Northrop Corp., Van Nuys, Calif., for flight services for target missile.

$61,000—The Martin Co., Orlando, for *Pershing* weapon system.

$44,741—U.S. Steel Corp., Consolidated Western Steel Div., Los Angeles, for repair parts for rocket motors.

$38,842—Sperry Rand Corp., Salt Lake City, for *Sergeant* missile ground handling equipment.

$33,112—Douglas Aircraft Co., Santa Monica, for *Nike* replenishment spare parts.

MISCELLANEOUS

Chesapeake Instrument Corp., Shadyside, Md., for design, development and fabrication of an ultrasonic measuring system for determining the temperature of the combustion products developed in the motor tube of a rocket engine during the firing cycle. Awarded by **Allegany Ballistics Laboratory of Hercules Powder Co.** Amount not disclosed.

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—when and where—

FEBRUARY

Institute of Radio Engineers, Prof. Group on Military Electronics, Los Angeles, Feb. 1-3.

American Rocket Society, Solid Propellant Rocket Conference, The Hotel Utah, Salt Lake City, Feb. 1-3.

Second Annual Symposium on Nondestructive Testing of Aircraft and Missile Components, (unclassified), South Texas Section of SNT and Southwest Research Institute, Gunter Hotel, San Antonio, Feb. 14-16.

Institute of Radio Engineers, International Solid-State Circuits Conference, 8th Annual Meeting, Sheraton Hotel and University of Pennsylvania, Philadelphia, Feb. 15-17.

American Society for Metals, Albuquerque and Los Alamos Chapters, Recent Developments in Materials for Nuclear Applications, University of New Mexico, Albuquerque, Feb. 16-17.

American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, St. Louis, Feb. 19-23.

Pacific Electronic Trade Show, Great Western Exhibit Center, Los Angeles, Feb. 26-Mar. 1.

American Institute of Chemical Engineers, National Meeting, Roosevelt Hotel, New Orleans, Feb. 26-Mar. 1.

Association of Iron and Steel Engineers, Los Angeles, Feb. 28-Mar. 2.

MARCH

Optical Society of America, Roosevelt Hotel, Pittsburgh, Mar. 2-4.

Gas Turbine Conference and Exhibit, sponsored by Gas Turbine Power Division of American Society of Mechanical Engineers and U.S. Department of Defense, Shoreham Hotel, Washington, D.C., Mar. 5-9.

American Congress on Surveying and Mapping, and American Society of Photogrammetry, Convention, Shoreham Hotel, Washington, D.C., Mar. 5-10.

Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by PGNS, AIEE, IAS, University of Pennsylvania, Philadelphia, Mar. 9-10.

American Rocket Society, Test Operations and Support Conference, Biltmore Hotel, Los Angeles, Mar. 13-16.

American Society of Mechanical Engineers, Aviation Conference, Statler Hotel, Buffalo, Mar. 13-17.

1961 Missile/Space Conference and Goddard Memorial Dinner of the National Rocket Club, Sheraton Park Hotel, Washington, D.C., Mar. 14-16.

IRE International Convention, Coliseum and Waldorf-Astoria Hotel, New York City, Mar. 20-23.

Nuclear Congress, Nuclear Engineering and Science Conference sponsored by 30 major engineering societies and Engineers Joint Council, Chicago, Mar. 20-24.

American Society for Metals, 12th Western Metal Congress, Ambassador Hotel and Western Metal Exposition in Pan-Pacific Auditorium, Los Angeles, Mar. 20-24.

FABMDS

...One of many projects in Systems Engineering at General Electric's Special Programs Section

FIELD ARMY BALLISTIC MISSILE DEFENSE SYSTEM

Modern battle concepts of the United States Army require new tactical and support systems. Because of their increasingly complex nature, extensive capabilities in systems management and systems engineering have assumed greater importance.

It was for this reason that General Electric's Special Programs Section was established. Typical of its current projects is a study program for a Field Army Ballistic Missile Defense System. This system involves the integration of sensor components, communications links, data processing units, guidance, the vehicle aerodynamics, structures, stability and control, together with its launching and support equipment — all within a compatible systems structure.

To accomplish its objectives, SPS is staffed with a select group of senior engineers who act as a technical team to make systems recommendations... plan and create systems configurations and detailed specifications... establish implementation schedules... conduct continuing evaluation studies... direct and coordinate sub-contractor efforts — both within General Electric and outside the company.

Each engineer at SPS is highly competent within a broad field of technology, and has a working knowledge of several allied disciplines. He may concentrate on different aspects of a variety of problems, or follow a project, such as FABMDS, through to its completion.

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"Finding the men who can staff the 23 technologies necessary is not an easy task. It calls for engineers who are interested in technical rather than administrative accomplishment. It calls for engineers who have the clarity of concept to discard convention. It calls for engineers unhampered by 'tunnel vision'—who can translate the tactical requirements of the future into engineering reality. It calls for engineers who can do the jobs and meet the qualifications shown on the right.

"Martin-Orlando—prime contractor for Pershing, Bullpup, GAM-83, Lacrosse, Missile Master and BIRDiE—is working on the threshold of the future. If you feel you would like to join us, are qualified, and would enjoy living in Florida, we would very much like to hear from you."

James G. Houser

Director, Technical and Research Staff

Martin-Orlando's Technical and Research Staff has immediate openings for high level engineers and scientists in all 23 technologies being studied. Among these are:

- **OPERATIONS RESEARCH**—Operations Research is of prime importance in the Technical and Research Staff and is conducted primarily on the systems level in such efforts as weapons systems analysis, operational gaming and simulation, and system modeling.
- **ELECTRONIC SYSTEMS**—conceptual design and evaluation of advanced systems. Of significant interest at this time are high resolution techniques, missile detection and guidance, analytical studies of new communication systems.
- **COMPUTER TECHNIQUES**—digital systems and logic design for unique weapon systems applications. Concept through prototype experience desired.
- **INFORMATION THEORY**—as applied to communications, guidance or radar systems with emphasis on information theory, information processing, statistical theory of communications, decision theory, optimum coding and detection.
- **INERTIAL GUIDANCE**—conceptual and analytical investigation of advanced inertial guidance systems. Experience should be in modern weapons systems with emphasis on systems analysis for employment of inertial guidance techniques, and/or conception and design of all or major portions of inertial guidance components.
- **GROUND SUPPORT EQUIPMENT CONCEPT AND DEVELOPMENT**—emphasis on mobile missile systems analysis. Backgrounds in missile and equipment handling, servicing equipment development, transport and transport vehicle evaluation, soil mechanics, hard based installations, and power generation systems are applicable. Experience with military logistics and tactical military operations highly desirable.

Other technologies in which immediate openings exist include: Electronic Packaging, Environments Prediction, Structures (Conceptual Analysis and Design), Human Factors, Missile Propulsion.

If you are interested in and qualify for senior level work with this highly select staff, please contact C. H. Lang, Employment Manager, The Martin Company, Orlando 31, Florida.

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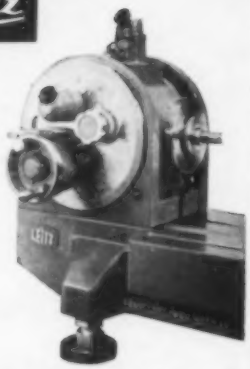

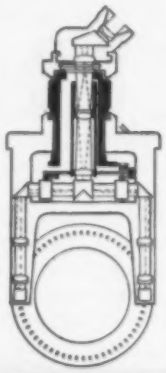

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editorial . . .

The *Nike-Zeus* Team

THE KENNEDY ADMINISTRATION is faced with a major decision on the *Nike-Zeus* program—concurrency or caution?

The urgent need for that decision is spelled out in the article by Defense Editor James Baar which leads off the special *Nike-Zeus* report beginning on p. 26 of this issue. The arguments for and against are clear. The decision should be made promptly.

Three months of editorial planning and thousands of miles of travel went into this 22-page special report. MISSILES AND ROCKETS editors visited *Nike-Zeus* facilities throughout the nation, talked to military experts concerned with the program and to dozens of the contractors and subcontractors working on the system. The result is the most comprehensive public report yet made on this controversial weapon system.

We are indebted to the Army and to the contractors for the full cooperation which made this possible.

Two things about the program particularly impressed us. One is the absolute confidence at every technical level that the *Nike-Zeus* system will work. If that confidence is justified, we can all sleep better at night. The other is the need for an immediate decision on production.

"How long can you hold a team together?" asked one manager. This was echoed elsewhere. In many ways, the *Nike-Zeus* team is the most experienced ever to work on a missile system. *Nike-Ajax* and *Hercules* provided valuable background. If a decision is delayed much longer, this team will begin to break up and drift away from the program. That would be tragic.

The Pentagon Team

THE NEW DEFENSE TEAM moved into the Pentagon last week with the words of President Kennedy's inaugural address still echoing through the breadth of the land.

Certain of the words of the new Commander-in-Chief must have sounded like a mandate: never fear to negotiate but never negotiate through fear; peace—but peace based on strength.

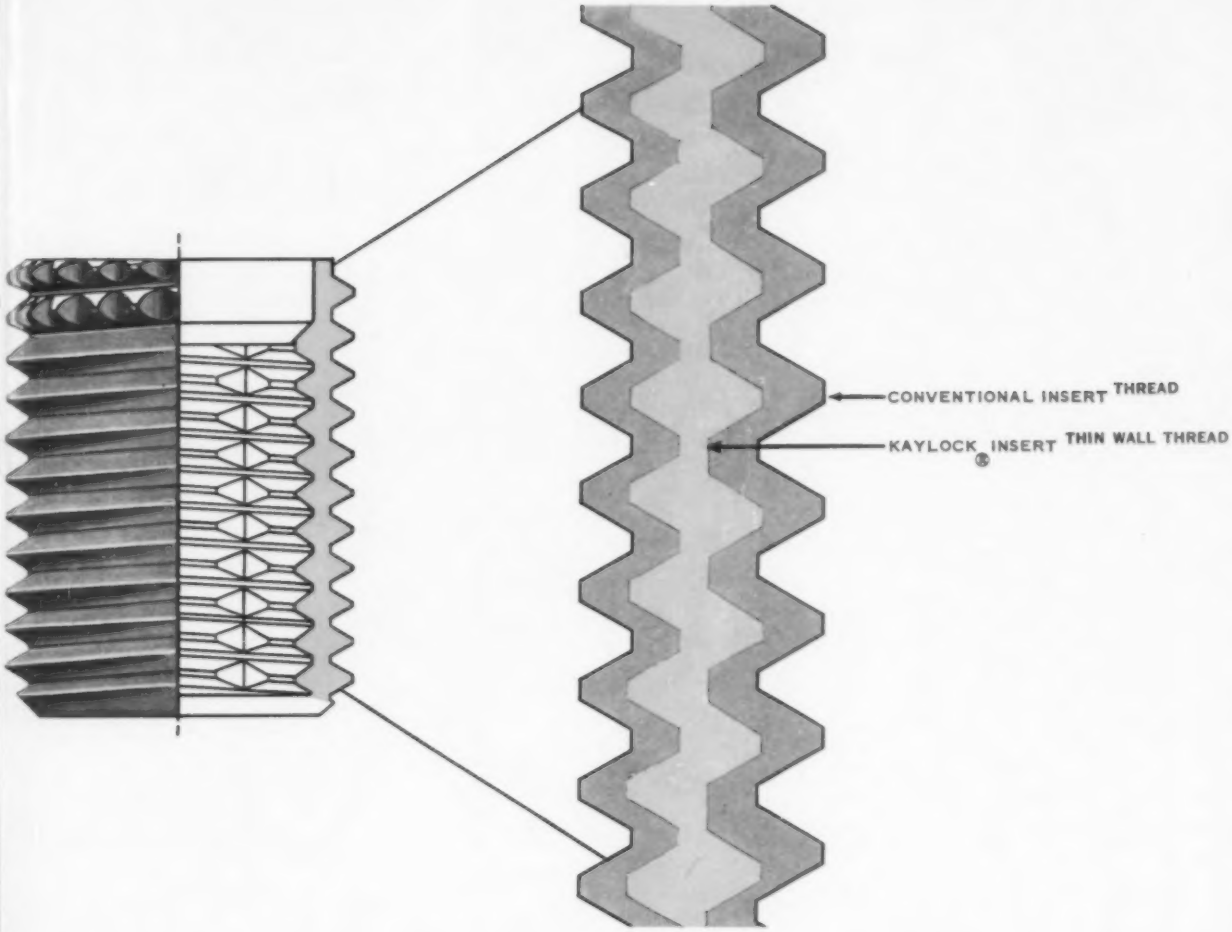
As Secretary of Defense Robert McNamara began his job, those who knew him expected him to move slowly but to move fairly. There were to be no big increases requested in the defense budget, no radical reorganizations of the U.S. defense structure sought in haste.

What were expected, though, were firm, hard decisions—a renouncement of vacillation. Said one member of the immediate defense team:

"You may want to say I'm wrong. You may want to say I'm intellectually stupid. But you'll never be able to say I failed to make decisions when they were needed."

McNamara was expected to organize his defense office along the lines most familiar to him —those of industry. As if the DOD were a corporation, McNamara will be president. Deputy Secretary Roswell L. Gilpatric will be vice president. The Secretaries of Army, Navy and Air Force—Elvis J. Stahr, John Connally and Eugene Zuckert—will be managers of divisions.

The new group will start, at least, with an attitude of "Don't try it—do it." There are many Pentagon people, many of them in the higher level posts, who will not fit into the concept McNamara & Co. have of the job to be done. They will not be permitted to linger.



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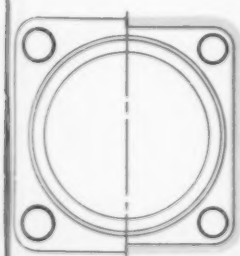

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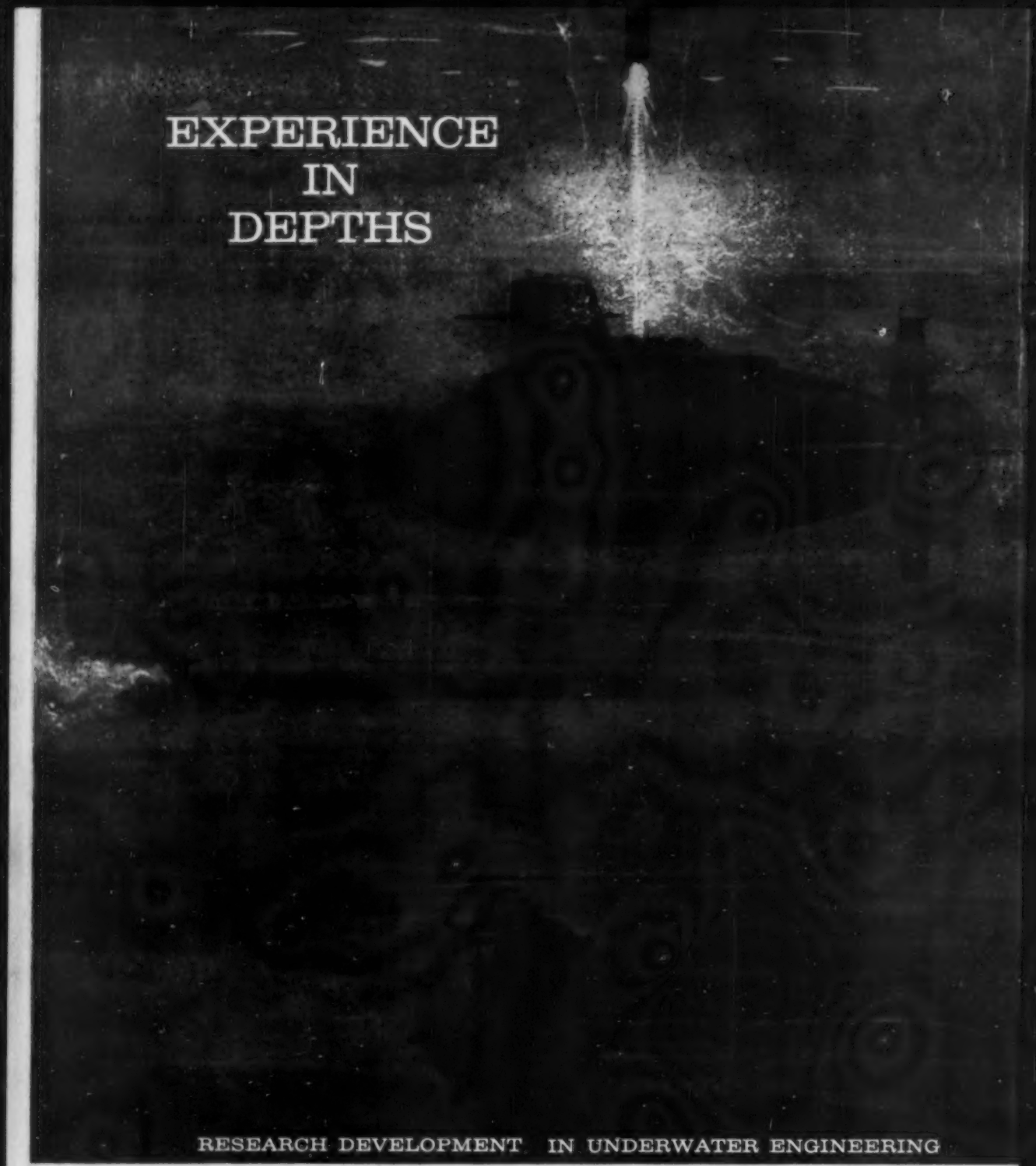

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